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A National Environmental/Energy Workforce Assessment. Post-Secondary Education Profile: Energy

National Field Research Center, Inc, Iowa City, IA

Prepared for

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16. ABSTRACT

This study is one of 16 volumes aggregating data on representative environmental education offerings in the United States at post-secondary education institutions and in the private sector of the economy. Structured around on-site interviews, the study describes the institutions' education programs — their program structure, representative course offerings, faculty structure, and program requirements. In addition, the study provides information on the employment history of graduates.

Designed as Phase II of a three-phase program, the study presents the information on schools in the following volumes: two volumes on potable water and two on wastewater; one volume each on air, noise, pesticides, radiation, solid waste and energy; a two-volume composite report on environmental engineering/health; a one-volume report on education/ecology; and a volume on some training programs conducted by businesses and by trade and professional associations. In addition, the study includes a one-volume abstract and a one-volume summary. The study is an overview. It doesn't include all environmental programs in the United States, and it makes no attempt to evaluate the program offerings.

Phase I of the study assessed the workforce needs (manpower needs) for pollution control and abatement in the United States for the five-year period of 1976 through 1981. Phase III, which will be available in September 1979, will offer recommendations, curriculum changes, and modifications that appear necessary to assure a properly trained national environmental workforce

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Water Pollution Solid Wastes Potable Water Pesticides Radiation Noise Pollution Energy Manpower	Environmental Engineering Environmental Health Environmental Education Environmental Protection Pollution Control Instruction Schools Education Ecology	National Environmental/Energy Workforce Assessment	

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Post Secondary Education Profile

ENERGY

Phase II
Of A National Environmental/Energy Workforce Assessment

Conducted by:

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NATIONAL ENVIRONMENTAL/ENERGY WORKFORCE ASSESSMENT

PHASE II

POST-SECONDARY EDUCATION PROFILE

ENERGY

Conducted by:

NATIONAL FIELD RESEARCH CENTER, INC.

Under Grant from:

UNITED STATES

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This document has been reviewed by the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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INTRODUCTORY NOTE

The National Environmental/Energy Workforce Assessment: Post-Secondary Education Profile was conducted by National Field Research Center, Inc. with main offices in Iowa City, Iowa. The following personnel have had primary responsibility for the development of the project report.

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Sincere appreciation is expressed to those persons within the United States Environmental Protection Agency, Office of Federal Activities, who provided guidance and direction throughout the term of the project: Mr. J. Donald Cook, Project officer; Mr. Joseph McCabe, and Mr. Michael Moore. Special thanks are also extended to Mr. Tahlman Krumm, Ohio State University.

Gratitude must be expressed to the many individuals and organizations from the private sector who were most generous in their contribution to this project. Their openness and responsiveness reflect their concern regarding the training of our environmental workforce and their critical role in that effort.

REVIEW COMMITTEE

A special word of acknowledgement is extended to the following people who graciously gave of their time, knowledge and experience in order to review and comment on the information included in this volume. The efforts of this national committee were particularly insightful, and in general have been incorporated into the final report.

It must be pointed out that in all cases the individuals acknowledged below were asked only to review and comment on the material contained in the volume and to express their views regarding the representativeness of the material presented. They were not asked to endorse either the volume or the study in general, and the inclusion of their name on this list should not be considered an endorsement since such was not the intent.

In light of numerous responsibilities, it is especially important to note that these persons responded within very strict time constraints. Such a pattern reflects positively on both the individuals and the institutions and organizations which they represent.

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FOREWORD

Information for this report was largely compiled from on-site interviews with professionals in post-secondary institutions throughout the United States. On-site interviews were supplemented by telephone and/or mail contact to clarify and revalidate the data. This report presents a summary of programs in junior colleges, vocational/technical training institutes, community colleges, four-year colleges, and universities as well as other training institutions. Programs are representative of all levels from academic certification through doctoral degrees. The environmental pollution control areas of air, noise, pesticides, potable water, radiation, solid waste, wastewater and energy were surveyed.

This study was conducted for the United States Environmental Protection Agency by the National Field Research Center, Inc. of Iowa City, Iowa, with field offices located in Atlanta, Georgia; Denver, Colorado; and Washington, D.C.

NATIONAL ENVIRONMENTAL/ENERGY WORKFORCE ASSESSMENT

PHASE II

POST-SECONDARY EDUCATION PROFILE

ENERGY SUMMARY

ENERGY

A. STATES, INSTITUTIONS, PROGRAMS AND DEGREES

Energy education programs offered by more than 30 schools in eighteen states were surveyed in Phase II. Because several schools offer more than one program, the report includes in excess of 40 programs in which 95 certificate or degree sequences are available.

The following table depicts the number of programs surveyed by degree.

TABLE 1

ENERGY DEGREES, PROGRAMS AND STATES

Degree	Number of Programs
Certificate	4
Associate	6
Bachelors	1
Multiple Degree Programs	
Associate/Bachelors	2
Bachelors/Masters	2
Associate/Bachelors/Masters/ Doctorate	1
Bachelors/Masters/Doctorate	11
Masters/Doctorate	2
Non-Degree Programs	2
TOTAL	31

States Visited

California
Connecticut
Florida
Indiana
Kansas
Kentucky
Massachusetts
New Jersey
New Mexico
New York
Ohio
Oregon
Pennsylvania
Tennessee
Texas
Utah
West Virginia

B. ENROLLMENT STATISTICS AND GRADUATES

Only one program respondent said recruitment is a major problem. Most replied that their efforts are adequate; several said that the program is involved in no active recruitment because student demand is high in response to high paying jobs awaiting graduates. Those who do recruit rely heavily upon brochures, university-wide recruiting efforts, and word-of-mouth among collegues and students.

Among the associate degree programs, 80 to 100% of the students are in-state. Among the bachelors programs, most range from 70-80% in-state; the high is 98%, the low, 33%. Masters and doctoral enrollments range from a high of 75% to a low of 20% in-state; most have fewer than 50% in-state.

The energy programs in the sample are extremely diverse; few characteristics are held in common throughout. Enrollments vary from fewer than 10 to more than 600. Nearly 60% of the students are in bachelors programs; of these, 99.5 are full-time. Associate degree programs account for slightly more than 25% of all students; 13% are enrolled in masters programs; and little more than 3% are in doctoral programs. Fewer than 5% of the students in energy education programs surveyed are women.

The following table presents the Energy Enrollment Profile Summary for the programs surveyed:

TABLE 2

ENERGY ENROLLMENT PROFILE

Degree	Enrollment Part Time/Full Time		Graduates Average # per year	Enrollment Change by Program Up/Down/Stable		
Associate	774	265	260	6	3	1
Bachelors	2,540	19	503	11	0	7*
Masters	503	199*	211	16	0	12
Doctoral	171	24	39	3	0	11
Graduate[1]	165	0	70	3		
Certificate (Master's level)	6	50	30	1		
TOTAL	4,159	557	1,113	39	3	31

* Complete figures are not available

[1] No breakdown among graduate students is available for some programs

Few programs have graduate follow-up information beyond entry level. Many who replied in the affirmative to graduate follow-up indicated it is on an informal basis.

C. FACULTY

Altogether, 231 (58%) full-time program faculty and 165 (42%) part-time (home-based in other departments) were recorded. Approximately half the programs rely exclusively or nearly so on full-time program personnel; several programs are made up of a core program faculty supplemented by several people cost-centered in other departments. Several multidisciplinary efforts are staffed by one person with coordinating responsibilities and a large number of faculty whose program participation may vary from active participation in administration, student advising, and curriculum decisions to assuming responsiblity for teaching a single course infrequently.

No meaningful student-faculty ratio can be developed due to the variance in method of program staffing and differences in teaching loads and research commitments.

D. CURRICULA

Programs in the report include well-established programs in nuclear engineering, and mining petroleum and natural gas technology and engineering. Additionally there are unusual programs in energy conversion, energy resources management, and several others which represent recent innovative approaches to a broad spectrum of energy problems.

Several programs indicated internships or applied study terms are an integral component of the educational experience. Seven of the associate programs either require or contain an active option of internships; 13 of the bachelors programs do so; as do nine of the masters programs. It is an option in a few doctoral programs. Several respondents singled out the applied study aspect as the most important component distinguishing their program from similar efforts.

Respondents were asked to indicate the normal time frame in which a change in a course or program sequence can be implemented. The time factor of program flexibility so indicated by energy programs is typical of most academic areas. Most course changes can be implemented within one year (usually for the succeeding term), although six programs noted more than a year is required. Program sequence changes, for the most part, take longer, but most are accomplished within a year. Faculty noted that it is an easier process to change curriculum at the graduate level than at the undergraduate level.

The need for additional curriculum materials appears to be of little concern except at the associate level. Faculty complained both of materials that are above and below the reading or technical level of associate degree students.

Respondents representing engineering programs often replied that communication skills are a problem of incoming students; there is some disagreement as to how well the problem is dealt with. Associate program faculty felt the level of communication skills of many of their students is a problem of major significance.

E. RESEARCH FUNDING AND SOURCES OF STUDENT FINANCIAL SUPPORT

Energy research support is widespread. As would be expected, the U.S. Department of Energy is the most prevalent source of research money. Other federal sources most commonly cited were the U.S. Bureau of Mines; the Environmental Protection Agency; Health, Education and Welfare; and the Nuclear Regulatory Commission. Many state agencies support projects. The National Science Foundation and the Ford Foundation provide much support, as do many industries, especially through institute contributions such as the Electric Power Research Institute and the American Iron and Steel Institute. Oil and gas companies and utilities contribute significantly.

Research and teaching assistantships are available in most graduate programs. Many student jobs are supported through research funding. Scholarships, fellowships, and student loans are readily available; work-study programs are common for undergraduates.

Engineering students are often eligible for a cooperative work program. Many students have industry grant support, often in the form of a traineeship.

F. EMPLOYMENT

The following table presents employment data for graduates of the energy education programs surveyed in Phase II. Figures were provided by faculty members and are either "best estimates" or actual statistics gathered.

TABLE 3

ENERGY EMPLOYMENT PROFILE

DEGREE	PRIVATE SECTOR			GOVERNMENT	OTHER
	Industry/	Combined*/	Consulting		
Associate	81%	8%		7%	4%
Bachelors	56%	8%	12%	18%	6%
Masters	55%	8%	9%	26%	2%
Nuclear Engineer	64%			18%	18%
Doctoral	21%	3%	9%	38%	29%
Graduate[1]			52%	48%	
Certificate	50%		45%	5%	

---

[1] Some programs were unable to break out Masters and Doctoral students.

*Some programs were unable to break private sector employment into separate categories of industry/consulting.

Respondents were provided a list of energy occupations. They were asked to indicate those occupations for which their graduates are prepared and to add appropriate positions to the list.

The occupations most cited were:

Degree Level	Occupations
Associate	Entry Level Miner (coal) Petroleum Engineer Technician Radio-Chemistry Technician
Bachelors	Chemical Engineer Energy Engineer Mining Engineer Nuclear Engineer Environmental Control Technologist Petroleum Geologist Technician
Graduate	Environmental Physicist Mechanical Enginner (Conversion) Energy Policy Analyst Electric Power Engineer

PROJECT BACKGROUND

Photo reprinted from the University of Wisconsin, Madison Oceanography and Limnology Catalog

PROJECT BACKGROUND

OVERVIEW:

In late 1975, Congress acknowledged the growing national concern for the preservation and conservation of our national resources with a direct inquiry into the availability and readiness of our environmental workforce. That inquiry has taken the form of a three-year, three-phase National Environmental/Energy Workforce Assessment, currently being conducted by National Field Research Center under the direction of the U.S. Environmental Protection Agency. In keeping with the objective of the assessment, this three-phase national effort directs itself at environmental/energy workforce needs, national educational preparedness, and the functional relationship between the two.

PHASE I:

Phase I of the National Environmental/Energy Workforce Assessment focused upon the development of "workforce demand projections" through 1982 for all public environmental agencies. This on-site assessment, which was carried out in all 50 states, Puerto Rico and the Virgin Islands, culminated in a numerical profile of the growth patterns and workforce needs at the national and state levels. Stratification of the overall definition of "environmental occupation" into seven distinct vocational areas enhanced even further the applicability of the results. In addition to this public sector workforce assessment, Phase I included an overview analysis of private sector needs (through an adjunct mail survey of selected businesses and industries) and a brief review of selected environmental educational programs.

Phase I was completed in May, 1977. The 70-volume final report included:

* National Abstract	(1)
* National Legislation	(1)
* Regional Assessments	(10)
* State Assessments (including D.C., VI and PR)	(53)
* Business and Industry Assessment	(1)
* National Summary	(4)

PHASE II:

Phase II of the National Environmental/Energy Workforce Assessment was structured around an intensive on-site inventory of representative environmental educational offerings on a national scale. The primary objective of this project has been to collect and aggregate data on training and educational programs in both the post-secondary education field and in the private sector and to do so by environmental area. Specifically, the study was designed to provide an overview of environmentally related post-secondary education programs, their program structure, representative course offerings, employment history of the graduates, and the faculty structure. Additionally, information was to be collected on program requirements and program projections.

Initially, opportunities to nominate programs for inclusion in this on-site review process was given to the Environmental Protection Agency and its program officers and regional personnel both through the

Project Officer and via direct mail requests; all state departments of education; state environmental agencies and selected media-specific associations. These nominations were supplemented by a direct review of institutional catalogs, information obtained during the first year's on-site activities, and a review of other published sources of information regarding degree programs in environmental areas. These sources are included in Appendix III - Selected Bibliography.

Following their initial development, the lists of nominees were forwarded to the program officers for suggestions regarding additions or deletions. Next, letters were written to those nominated institutions seeking their support and cooperation in the on-site review process. Several programs, some of which were highly recommended, declined the opportunity to participate giving reasons varying from lack of time to the fact that the program being inquired about no longer existed, to outright refusal to cooperate with any government study. These institutions were deleted from the final on-site process. The remainder were included in the study and are shown in Table 1 of each volume. Selection of the sample for the private sector is discussed in depth in that particular volume.

In preparation for the on-site interviews, appropriate persons were contacted in the institution involved and were given a background description of the study, a suggested timetable for the interview process and were told what kind of information was being sought. This was all done in an effort to keep the time involvement of the individual contact persons at a minimum. During the actual on-site interview, generally lasting around one hour, the information was collected, questions asked and answered, and further informational contacts identified. Following this process, each on-site interview was written up in the form of a Training Program Summary, which where time allowed, was returned to the contact person for critiquing prior to inclusion in the report.

Throughout this process, individuals and institutions were given assurance that this study was not an attempt to evaluate program offerings and every attempt has been made on the part of the writers to live up to this assurance. Inclusion in this report provides no assurances of quality, nor should a program's exclusion be consideration of the lack thereof. In many instances certain programs within an institution were not included while others were, primarily due to the determination of the sample - previously discussed. This too should not be viewed in any qualitative manner.

REPORT ORGANIZATION:

The final report, of which this volume is a part, consists of volumes depicting a training profile in each medium under consideration, namely,

Air
Energy
Noise
Pesticides
Potable Water
Radiation
Solid Waste
Wastewater
Composite
Business and Industry and Trade Associations

At the outset it should be pointed out that there are very few degree programs conveying degrees in a particular medium; rather, degrees are offered in various specialties which lend themselves to obtaining employment in one or more of these fields. Nonetheless, to obtain maximum utility for the funding agency, programs were reported in this fashion. The Composite section was necessitated by the number of programs offering course work in multiple fields and differing specializations resulting from course selection. For convenience in handling of the data Potable Water, Wastewater and Composite have been reported in multiple volumes because of the numbers involved. Although separated into volumes either by degree level of the programs involved, as in the case of Potable Water and Wastewater, or by content as in the case of Composite, persons interested in any of these fields would be well advised to review each of the volumes to assure more complete coverage.

Along with the standard introductory pages common to volumes of this nature, each volume contains sections on Project Background, Introduction (consisting of sections devoted to a description of the programs surveyed and covered in the volume), Project Commentary, and the Training Summaries along with the Appendices.

REVIEW PROCESS:

In addition to individual training summary reviews conducted by the persons initially interviewed, each volume has been reviewed internally, by persons in the Environmental Protection Agency and by a select group of review committee members. In the final instance, individuals met during the on-site process were nominated by interviewers for inclusion on the review committee, primarily as a result of their obvious expertise in the field and their evidenced interest in the project.

These persons were then contacted by mail or by telephone in an effort to determine their willingness to serve. The rather stringent timelines necessary to keep the project on course and to deliver the finished product as specified were also detailed. In excess of one hundred persons returned their volumes (out of a mailing of 120) and all but five of these provided usable responses. In these five instances either last minute job demands prevented them from carrying out the review in the short timelines, or (in two instances) individuals indicated that they wanted nothing to do with the process. This particular method of review provided a wealth of valuable information, suggestions for revision of specific elements, and general comments helpful in revising the final documents. In all cases an effort was made to seriously consider and incorporate reviewer suggestions. The persons on the various review committees are individually acknowledged in the front of the volume they reviewed.

Photo reprinted from the University of Missouri, Columbia Bulletin 1977.

INTRODUCTION

Photo reprinted from the Northland College Catalog 1975-76

INTRODUCTION

Energy is a topic of increasing national concern. Frequently Americans are confronted with decisions that are no longer easy to make because energy usage, conversion, and conservation are now realized to be significant factors for consideration. Daily the centrality of energy matters to national issues and personal lifestyles is becoming more obvious.

Interviews conducted during Phase I of the National Environmental/Energy Workforce Assessment revealed a growing awareness of the need for a comprehensive energy policy at all governmental levels. Coupled with that heightened awareness was the expression of concern that persons presently in positions requiring energy related decision making were ill-prepared to do so. Such comments were often followed by remarks concerning a rising need for persons trained in energy/management skills. The concurrent need for a larger, better-trained workforce at all levels of energy activities was seldom slighted by respondents. Many also voiced concern that headway in pollution reduction might be lost as energy matters increase in priority. People often added that increasing the proportion of the energy research funding allotted to alternative sources is essential to obtaining sufficient energy for a dynamic society in an environmentally sound manner.

The programs included in this volume are evidence that people are doing more than just talking about our energy future. In addition to well-established programs in nuclear engineering, mining, petroleum and natural gas technology and engineering; there are programs such as Cornell's College Program in Energy Conversion, the interdepartmental Energy Engineering and Policy program at the Polytechnic Institute of New York, the Energy Conversion and Resources Topical Program at Princeton, the undergraduate Energy Resources Management program of Lamar University, the graduate University of Pennsylvania Energy Management and Policy multidisciplinary program, and several others which represent recent innovative approaches to a broad spectrum of energy problems.

Each of the programs surveyed in energy is described individually in the Energy Educational/Training Summaries section of this report. The selected course offerings included in each program summary are indicative of the range and depth of energy education. The summaries include program descriptions which detail program structure and requirements; a faculty, student, and graduate profile; and a program projection commentary.

The reader is also referred to Table 9, on page 67 , which provide data summaries for the degree programs as to such variables as enrollment, graduates, faculty, graduate employment, and applied study term programs. Additional information is presented on these programs in narrative and tabular form, which are detailed in the Table of Contents.

For a complete listing of all schools and programs included in the Phase II study, see Table 1, which follows.

TABLE I

PARTICIPATING INSTITUTIONS

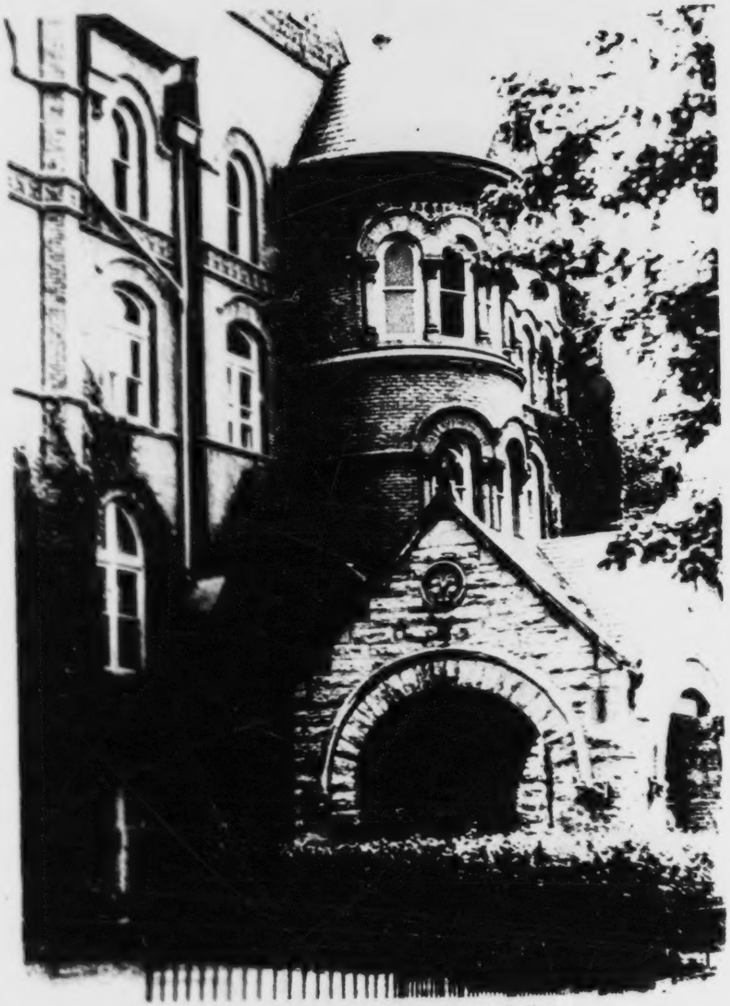

Photo reprinted from the Macalester College
1976-78 Catalog

Table 1 is a comprehensive listing of all institutions which participated in the post-secondary educational profile of the National Environmental/Energy Workforce Assessment. Listed by state, institution, and degree are programs surveyed in the areas of air, energy, noise, pesticides, potable water, radiation, solid waste and wastewater.

An explanation of the degree abbreviations utilized within the report may be found in Appendix I, entitled "Degree Abbreviations". For a complete listing of the institutions visited in a media specific area (i.e., air, energy, etc.), attention is drawn to Appendix IV, entitled "Participating Institutions by Environmental Category".

The Table in part III of the Project Findings, entitled "A Summary Profile of Representative Educational Programs" follows the narrative and is a presentation of specific institutions visited for the particular volume.

TABLE I

PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)*
AL	University of Alabama University	Environmental Engineering	M.S. (3)
AK	University of Alaska Fairbanks	Environmental Quality Engineering Science	M.S.
AR	University of Arkansas Fayetteville	Agricultural Engineering	B.S. M.S. Ph.D.
		Civil Engineering	M.S.C.E.
		Environmental Engineering	M.S.En.E.
		Environmental Science	B.S.
CA	California Institute of Technology Pasadena	Environmental Engineering Science	M.S. Ph.D.
	California Polytechnic State University San Luis Obispo	Environmental Engineering	B.S.
	California State University-Sacramento Sacramento	Civil and Environmental Engineering	B.S. M.S.
	Stanford University Stanford	Environmental and Water Studies	M.S. Ph.D.
	University of California-Berkeley Berkeley	Nuclear Engineering	B.S. M.S. M.E. Ph.D. D.E.
		Pest Management	B.S.
		Sanitary Engineering	M.S. M.E. Ph.D.
	University of California-Davis Davis	Environmental Toxicology	B.S.
		Plant Protection and Pest Management	M.S.

TABLE I

PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	University of California-Davis (Cont'd)	Entomology	B.S. M.S. Ph.D.
	University of California-Riverside Riverside	Pest Management	M.S.
	University of California-Santa Barbara Santa Barbara	Environmental Studies	B.A.
CO	Colorado State University Fort Collins	Environmental Engineering (Civil)	M.S. Ph.D.
	Community College of Denver-Red Rocks Golden	Water-Wastewater Technology	A.A.
CT	Hartford State Technical College Hartford	Nuclear Engineering Technology	A.S.
	Yale University New Haven	Environmental Health	M.P.H.
DE	Delaware Technical and Community College Newark	Environmental Engineering Technology	A.A.S.
	University of Delaware Newark	Entomology and Applied Ecology	B.S.
		Environmental Engineering	M.A.S. M.E. Ph.D.(App. Science) Ph.D.(ChE)
DC	Catholic University Washington	Civil Engineering	B.S.
	Howard University	Environmental Engineering	M.E.

TABLE I

PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
FL	Broward Community College Fort Lauderdale	Pest Control Technology	A.S.
	Central Florida Community College Ocala	Radiological Health Technology	A.S.
	Florida International University Miami	Environmental Studies	B.A. B.S.
		Environmental Engineering Technology	B.S.
	Heed University Hollywood	Ocean and Environmental Affairs	M.A. Ph.D.
	Miami-Dade Community College Miami	Environmental Engineering Technology	A.S.
		Marine Science Technology	A.S.
	University of Florida Gainesville	Air Pollution	M.E. M.S. Engineer Ph.D.
		Environmental Biology	M.E. M.S. Engineer Ph.D.
		Environmental Resources Management Activities	M.E. M.S. Engineer Ph.D.
		Systems Ecology	M.E. M.S. Engineer Ph.D.

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PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	University of Florida (Cont'd)	Water Supply and Water Pollution Control	M.E. M.S. Engineer Ph.D.
		Nuclear Engineering	B.S.(N.E.) B.S.E.(N.E.) M.E. M.S. Engineer Ph.D.
		Radiological Sciences	M.E. M.S.
	University of Miami Miami	Marine and Atmospheric Science	M.S. Ph.D.
GA	Abraham Baldwin Agricultural College Tifton	Plant Protection	A.Ag.
	Atlanta University Center/ Georgia Institute of Technology Atlanta	Water Pollution Control Design Engineering	B.S. B.E.
	Georgia Institute of Technology Atlanta	Acoustical Engineering	Advanced Cert.
		Energy Engineering	Advanced Cert.
		Environmental Studies	Advanced Cert.
	Southern Technical Institute Marietta	Nuclear Safety	A.S.
	University of Georgia Athens	Entomology	B.S. A.B. M.S. M.P.P.P.M. Ph.D.

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PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	University of Georgia (Cont'd)	Environmental Health Science	B.S.E.H.
HI	University of Hawaii Honolulu	Environmental and Sanitary Engineering	M.S.
IL	Illinois Institute of Technology Chicago	Environmental Engineering	B.S.E.S. M.S. Ph.D.
	Prairie State Community College Chicago Heights	Air, Water, Wastewater	A.A.S.
	Sangamon State University Springfield	Environments and People	B.A. M.A.
	Southern Illinois University-Edwardsville Edwardsville	Wastewater Treatment Operator Training	Cert.
IN	Indiana University Bloomington	Environmental Programs	Cert. A.S. B.A. B.S. M.P.A. M.S.E.S. Ph.D. (minor)
	Purdue University West Lafayette	Environmental Sciences Option	B.S.
		Nuclear Engineering	B.S.N.E. M.S. Ph.D.
IA	Iowa State University Ames	Environmental Studies	B.A. B.S.
		Sanitary Engineering and Water Resources	M.S. Ph.D.

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PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Kirkwood Community College Cedar Rapids	Environmental Health Assistant	Diploma
		Environmental Health Technician	A.A.
		Water and Wastewater	Diploma
	University of Iowa Iowa City	Environmental Engineering	M.S. Ph.D.
		Environmental Toxicology	M.S. Ph.D.
KS	Kansas State University Manhattan	Chemical Engineering	B.S. M.S. Ph.D.
		Mechanical Engineering	B.S. M.S. Ph.D.
		Nuclear Engineering	B.S. M.S. Ph.D.
		Sanitary Engineering	M.S.C.E.
	University of Kansas Lawrence	Environmental Health Engineering	M.S. Ph.D.
		Environmental Health Science	M.S. Ph.D.
		Environmental Studies	B.A.
		Radiation Biophysics	B.A. B.S. M.S. Ph.D.
		Water Resources Engineering and Science	M.S. Ph.D.

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PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
KY	Morehead State University Morehead	Environmental Studies	B.S. A.B.
		Mining Technology	A.A.S.
	Pikeville College Pikeville	Mining Technology	A.M.T.
	University of Kentucky Lexington	Energy (Coal) Engineering	M.S. Ph.D.
		Environmental Engineering	M.S. Ph.D.
	University of Louisville Louisville	Environmental Engineering	B.S. M.Eng.
	Western Kentucky University Bowling Green	Environmental Science	B.S.
		Environmental Engineering	B.S.
LA	Delgado College New Orleans	Urban Pest Management	A.S.
		Water/Wastewater Technology	A.S.
		Environmental Health Technology	A.S.
	McNeese State University Lake Charles	Environmental Science	B.S. M.S.
ME	Eastern Maine Vocational Technical Institute Bangor	Environmental Control Technology	A.A.S.
	New England Regional Wastewater Institute (S. Maine Vocational Technical Institute) S. Portland	Wastewater Treatment Technology	Cert.

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PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	University of Maine-Orono Orono	Sanitary Engineering	M.S.C.E. Ph.D.
MD	Charles County Community College La Plata	Pollution Abatement Technology	A.A.
	Johns Hopkins University Baltimore	Environmental Engineering	M.A. M.S.E. M.S. Ph.D
	University of Maryland College Park	Environmental Engineering	M.S.
		Nuclear Engineering	M.S.
		Pest Management	M.S.
MA	Harvard University Cambridge	Environmental Health Sciences	S.M. Sc.D.
		Environmental Sciences and Engineering	S.M. M.E. Ph.D.
		Toxicology	S.M. Sc.D.
	Massachusetts Institute of Technology Cambridge	Acoustics	S.M. Sc.D./Ph.D.
		Environmental Engineering	Env.E.
		Mineral Resources Engineering and Management	S.M. Engr. Sc.D./Ph.D.

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PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Massachusetts Institute of Technology (Cont'd)	Nuclear Engineering	S.B. S.M. N.E. Sc.D./ Ph.D.
		Water Resources and Environmental Engineering	S.B. S.M. Sc.D./ Ph.D.
		Wastewater Treatment Plant Operations	Cert.
	Northeastern University Boston	Environmental Engineering and Science	M.S.
	Springfield Technical Community College Springfield	Environmental Technician	A.S.
	Tufts University Medford	Environmental Health Engineering	B.S.C.E. M.S.
	University of Lowell Lowell	Radiological Health Physics/Radiological Sciences and Protection	B.S. M.S.
		Wastewater Treatment Plant Operations	Cert.
MI	Ferris State College Big Rapids	Environmental Health Technician	A.A.S.
		Environmental Health	B.S.
	Michigan State University East Lansing	Environmental Conservation Education	M.S. Ph.D.
		Environmental Engineering	B.S.C.E. M.S. (emphasis) Ph.D. (emphasis)

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PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Michigan State University (Cont'd)	Natural Resources and Environmental Education	B.S.
		Systems Science (Ecological Systems)	B.S. M.S. Ph.D.
	Michigan Technological University Houghton	Environmental Engineering	B.S.C.E. B.S.E. M.S.C.E.
	University of Michigan Ann Arbor	Environmental Education	M.S.
		Environmental Sciences Engineering	B.S.
		Industrial Hygiene and Air Pollution	M.P.H. M.S. Dr.P.H. Ph.D.
		Radiological Health	M.P.H. M.S. Dr.P.H. Ph.D.
		Water Resources: Engineering	M.S.E. Ph.D.
		Management Science	M.S. Ph.D.
		Water Quality	M.P.H. M.S. Dr.P.H. Ph.D.
MN	Bemedji State College Bemedji	Environmental Studies	B.S. M.A.
	Macalester College St. Paul	Environmental Studies	B.A. B.S.
	University of Minnesota Minneapolis	Environmental Health	M.P.H. M.S. Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
MS	Mississippi State University Mississippi State	Specialized Training in Pest Management	M.Ag.
MO	Missouri Southern State College Joplin	Environmental Health Technology	A.S. B.S.
		Radiologic Technology	A.S.
	St. Louis Community College at Forest Park St. Louis	Radiologic Technology	A.S.
	University of Missouri-Columbia Columbia	Sanitary Engineering	B.S. M.S. Ph.D.
	University of Missouri-Rolla Rolla	Environmental and Sanitary Engineering	M.S. Ph.D.
	Water and Wastewater Technical School Neosho	Water and Wastewater Training	Cert.
	Washington University St. Louis	Air (emphasis)	M.S. D.Sc.
MT	Montana State University Bozeman	Environmental Engineering	M.S.
		Environmental Health Technology	M.S.
	Northern Montana College Havre	Environmental Health Technology	A.A. Cert.
NE	Central Technical Community College Hastings	Agriculture Technology	Cert. 1-Year Diploma 2-Year Diploma A.A.S. A.S.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	University of Nebraska Lincoln	Sanitary Engineering	B.S. M.S. Ph.D.
		Water Resources Engineering	M.S.
		Planning and Management	M.S.
NH	University of New Hampshire Durham	Entomology	B.S. B.A.
NJ	Middlesex County College Edison	Environmental Health Science Technology	A.A.S.
	New Jersey Institute of Technology Newark	Interdisciplinary Studies in Environmental Engineering	M.S.
	Princeton University Princeton	Energy Conversion and Resources	Topical Programs
	Rutgers-SUNJ New Brunswick	Biology (option in entomology)	B.S. B.A.
		Entomology and Economic Zoology	M.S. M.P. Ph.D.
		Environmental and Business Economics	B.S.
		Environmental Science	M.S. Ph.D.
		Environmental Studies	B.S.
		Environmental and Water Resources Engineering	M.S. Ph.D.
		International Environmental Studies	B.A. B.S.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Rutgers-SUNJ (Cont'd)	Radiation Sciences	M.S. Ph.D.
	Stevens Institute of Technology Hoboken	Air Pollution Control Engineering	Cert.
		Water and Wastewater Engineering	Cert.
NM	New Mexico State University Las Cruces	Pest Management	B.S.
	University of New Mexico Albuquerque	Nuclear Engineering	M.S. Ph.D.
NY	Clarkson College Potsdam	Civil and Environmental Engineering	B.S. M.S.
	Columbia University New York City	Nuclear Engineering	B.S. M.S. Nuc.Engr. Eng.Sc.D.
	Cornell University Ithaca	College Program in Energy Conversion	B.S.
		Environmental Engineering	B.S. M.S. M.Eng. Ph.D.
		Waste Management Engineering	M.S. M.Eng. M.P.S. Ph.D.
		Nuclear Engineering	M.Eng. M.S. Ph.D.
	Hofstra University Hempstead	Solid Waste Management	Cert.
	Hudson Valley Community College Troy	Public Health Technology (Environmental option)	A.A.S.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Hunter College New York City	Environmental Health Science	B.S. M.S.
	Manhattan College New York City	Environmental Engineering and Science	M.S. M.E.
	Polytechnic Institute of New York New York City	Energy Engineering and Policy	Cert. M.S.
		Environmental Engineering and Planning	M.S.C.E. M.E.H.S. Engr. Ph.D.
	Rensselaer Polytechnic Institute Troy	Environmental Engineering	B.S. M.E. M.S. D.E. Ph.D.
		Nuclear Engineering	B.S. M.S. M.E. Ph.D.
	Rochester Institute of Technology Rochester	Civil Engineering Technology (Environmental option)	B.T.
	State University of New York-Buffalo Buffalo	Water Resources and Environmental Engineering	B.S. M.S. Ph.D.
	State University of New York Farmingdale	Pest Control Technology	A.A.S.
	Syracuse University Syracuse	Chemical Engineering	B.S. M.S. Ph.D.
		Environmental Engineering	B.S.
		Sanitary Engineering, Sanitary Science, Civil Engineering	M.S.(S.E.) M.S.(S.S.) Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	The Cooper Union New York City	Integrated Master's Program with concentration in Environmental Engineering	M.E.
	Ulster County Community College Stone Ridge	Water Quality Management Training	A.A.S.
	University of Rochester Rochester	Toxicology Training Program	M.S. Ph.D.
NC	Duke University Durham	Environmental Management	M.E.M.
		Civil Engineering/Urban and Environmental Engineering	M.S. Ph.D.
	North Carolina State University Raleigh	Agricultural Pest Control	A.A.S.
		Pest Management	B.S. M.S. (minor)
		Air Conservation	M.S. (minor) M.E. (minor) Ph.D.(minor)
		Environmental Engineering	M.S. M.C.E. Ph.D.
		Acoustic, Noise Vibration	M.S. M.M.E. Ph.D.
	University of North Carolina Chapel Hill	Air and Industrial Hygiene	M.S. M.S.P.H.
		Environmental Chemistry and Biology	M.S. M.S.P.H. Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	University of North Carolina (Cont'd)	Environmental Management Protection	M.S. M.S.P.H. Ph.D.
		Radiological Hygiene	M.S. M.S.P.H. Ph.D.
		Water Resources Engineering	M.S. M.S.P.H. M.S.E.E. Ph.D.
	Wilson County Technical Institute Wilson	Sanitary Landfill Operating Manager	Cert. Diploma A.A.S.
		Sanitary Landfill Technology	A.A.S.
ND	North Dakota State School of Science Wahpeton	Environmental Science Technology	A.A.
OH	Antioch College Yellow Springs	Environmental Studies	B.S.
	Hocking Technical College Nelsonville	Environmental Health Technology	A.A.S.
	Miami University Oxford	Environmental Science	M.En.
	Muskingum Area Technical College Zanesville	Environmental Quality Control Technology	A.A.S.
		Natural Resources Conservation Technology	A.A.S.
		Petroleum Engineering Technology	1-Year Cert. A.A.S.
	Ohio State University Columbus	Agricultural Engineering	B.S. M.S. Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Ohio State University (Cont'd)	Chemical Engineering (air)	B.S. M.S. Ph.D.
		Civil Engineering	B.S. M.S. Ph.D.
		Environmental Biology	M.S. Ph.D.
		Environmental Education	B.S.(Ed.) B.S.(N.R.) M.S. Ph.D.
		Toxicology (Pharmacology)	M.S. Ph.D.
	Ohio University Athens	Environmental Studies	M.S.
	Raymond Walters General and Technical College (University of Cincinnati) Cincinnati	Environmental Control/ Protection Technology	A.S.
	University of Cincinnati Cincinnati	Air Pollution and Industrial Hygiene	M.S. Ph.D.
		Civil and Environmental Engineering	M.S. Ph.D.
		Environmental Health	M.S. Ph.D.
		Mechanical and Industrial Engineering (noise)	B.S. M.S. Ph.D.
		Occupational Medicine	M.S. Ph.D.
		Toxicology	M.S. Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	University of Cincinnati (Cont'd)	Acoustics and Noise Control	B.S. M.S. Ph.D.
	University of Toledo Toledo	Chemical Engineering, Civil Engineering	B.S. M.S.
		Engineering Science	M.S.
OK	East Central Oklahoma State University Ada	Environmental Science	B.S.
	OSU Oklahoma City Technical Institute Oklahoma City	Civil Technology	A.S.
	Oklahoma State University Stillwater	Engineering Technology	A.D. B.S.
		Radiation and Nuclear Engineering Technology	A.D. B.S.
	Oscar Rose Junior College Midwest City	Wastewater Technology	A.A.S.
		Environmental Science	A.A.S.
	University of Oklahoma Norman	Environmental Science	B.S. M.S. Ph.D.
OR	Linn-Benton Community College Albany	Wastewater Technology	A.S.
		Water/Wastewater Technology	A.S.
		Water/Wastewater Plant Operator	Cert.
	Oregon Institute of Technology Klamath Falls	Environmental Technology	A.A.S. B.T.
	Oregon State University Corvallis	Nuclear Engineering Technology	B.S.
		Nuclear Engineering	B.S. M.S.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Oregon State University (Cont'd)	Pest Management and Plant Pathology	B.S. M.S.
	Portland State University Portland	Engineering and Applied Science	B.S. M.S.
PA	Carnegie-Mellon University Carnegie Institute of Technology Pittsburgh	Environmental Engineering	B.S. M.S. Ph.D.
	Drexel University Philadelphia	Environmental Engineering and Science	M.S.E.E. M.S.E.S. Ph.D.
	Pennsylvania State University University Park	Acoustics	M.E. M.S. Ph.D.
		Air Pollution Control Technology	A.A.P.C.T.
		Entomology	B.S. M.Agr. M.S. Ph.D.
		Environmental Engineering	B.S. M.S. M.E.E.E. Ph.D.
		Environmental Pollution Control	M.S. M.E.P.C. M.E.
		Environmental Resource Management	B.S.
		Minerals Processing	M.S. Ph.D.
		Mining Technology	A.A.S.

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PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Pennsylvania State University (Cont'd)	Mining Engineering	B.S. M.S. M.E. Ph.D.
		Nuclear Engineering Technology	A.N.E.T.
		Nuclear Engineering	B.S. M.S. M.E. Ph.D.
		Petroleum and Natural Gas Engineering	B.S. M.S. Ph.D.
		Water Resources Engineering Technology	B.T.
	Slippery Rock State College Slippery Rock	Environmental Studies	B.S.
	Temple University Philadelphia	Environmental Technology	A.T.
		Environmental Engineering Technology	B.S.
	University of Pennsylvania Philadelphia	Energy Engineering	M.S.E.
		Energy Management and Policy	M.S.E.M.P. Ph.D.
	University of Pittsburgh Pittsburgh	Environmental and Sanitary Engineering	B.S. M.S. Ph.D.
		Environmental Systems Engineering	degrees granted through Engr. Dept.
	School of Public Health (University of Pittsburgh) Pittsburgh	Acoustic Environmental Control	M.S.(Hyg.) D.S.(Hyg.)
		Air Resources	M.S.(Hyg.)

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PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	School of Public Health (University of Pittsburgh) (Cont'd)	Environmental Health Engineering	M.P.H. D.S.(Hyg.)
		Environmental Health Planning	D.S.(Hyg.)
		Health Aspects of Water Quality	M.S.(Hyg.)
		Industrial Hygiene	M.S.(Hyg.)
		Toxicology	D.S.(Hyg.) Ph.D.
		Radiation Health	M.S.(Hyg.) D.S.(Hyg.) Ph.D. D.P.H.
RI	University of Rhode Island Kingston	Environmental Engineering	B.S. M.S. Ph.D.
SC	Clemson University Clemson	Air Pollution	M.S. M.Engr.
		Natural Systems	M.S. M.Engr.
		Planning and Management	M.S. M.Engr.
		Water Treatment Systems	M.S. M.Engr.
		Environmental Systems Engineering	Ph.D.
	Greenville Technical College Greenville	Wastewater Technology	A.A.S.
	Sumter Area Technical College Sumter	Environmental Engineering Technology	A.E.T.
TN	Chattanooga State Technical Community College Chattanooga	Environmental Science Technology	A.S.
		Nuclear Technology	A.S.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	East Tennessee State University Johnson City	Environmental Health	B.S.E.H. M.S.E.H.
	Memphis State University Memphis	Audiology	M.A. Ph.D.
	Middle Tennessee State University Murfreesboro	Environmental Science and Technology	B.S.
	State Technical Institute at Memphis Memphis	Environmental Engineering Technology	A.E.
	University of Tennessee Knoxville	Environmental Engineering	M.S.E.E. M.E. Ph.D.
		Environmental Engineering (Air Quality and Pollution Control)	M.S.E.E. M.E. Ph.D.
		Environmental Engineering (Water Pollution Control/ Water Resources)	M.S.E.E. M.E. Ph.D.
		Industrial Audiology	M.A.
		Nuclear Engineering	B.S. M.E. M.S. Ph.D.
		Water Resources Development	M.S.
	Vanderbilt University Nashville	Environmental and Water Resources Engineering (EWRE)	B.E.
		Environmental Science	B.S.
		EWRE (Environmental Science)	M.S. M.Eng. Ph.D.

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STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
	Vanderbilt University (Cont'd)	EWRE (Air Resources)	M.S. M.Eng. Ph.D.
		EWRE (Solid Waste)	M.S. M.Eng. Ph.D.
		EWRE (Water and Wastewater Treatment/Water Resources)	M.S. M.Eng. Ph.D.
TX	Baylor University Waco	Institute of Environmental Studies	B.A. B.S.
	Lamar University Beaumont	Environmental Science	B.S.
		Energy Resource Management	B.S.
	Rice University Houston	Environmental Science and Engineering	M.S.
	Sam Houston State University Huntsville	Environmental Science	B.S.
	Texas A & M University College Station	Environmental Engineering	M.S. Ph.D.
		Entomology	M.S.
		Entomology/Pest Management Option	M. Ag.
	Texas State Technical Institution Waco	Nuclear Technology	A.A.S.
		Water/Wastewater Technology	A.A.S.
		Water Utility Operator	Certificate
	University of Texas Austin	Environmental Health Engineering	M.S. Ph.D.
		Water Resources Engineering	M.S. Ph.D.

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PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
UT	Brigham Young University Provo	Chemical Engineering	B.S. M.S.
		Water Resources and Environmental Engineering	B.S. M.S.
	University of Utah Salt Lake City	Civil Engineering	B.S. M.E. M.S. Ph.D.
	Utah State University Logan	Civil and Environmental Engineering	B.S. M.S. Ph.D.
		Pest Management	B.S. M.S.
		Environmental Studies	B.S.
VA	George Washington University NASA-Langley Institute Hampton	Acoustics	M.S. Sc.D.
		Environmental Modeling	M.S.
	J.Sargeant Reynolds Community College Richmond	Environmental Technology Environmental Operations	Cert. A.A.S.
		Ground Water Resources	Cert.
	Virginia Polytechnic Institute and State University Blacksburg	Civil Engineering Technology	B.S.
		Sanitary Engineering/ Environmental Sciences and Engineering/Civil Engineering	M.S. Ph.D.
	Wytheville Community College Wytheville	Environmental Technology	Cert.

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PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
WA	The Evergreen State College Olympia	Coordinated Studies	B.A.
	University of Washington Seattle	Environmental Studies	B.A. B.S.
		Air Resources	M.S. Ph.D.
	Washington State University Pullman	Environmental Science	B.S. M.S.
		Chemical Engineering	M.S.
		Air Pollution Control Engineering	M.S.
		Air Pollution Science	M.S.
		Air Pollution Option	M.S.
		Air Pollution Program	M.S.
	Western Washington University Bellingham	Environmental Studies	B.S.
WV	Bluefield State College Bluefield	Mining Engineering Technology	A.S. B.S.
	West Virginia Institute of Technology Montgomery	Mining Engineering Technology	A.S.E.M.T. B.E.M.T.
	West Virginia University Morgantown	Engineering of Mines	B.S.
		Environmental Engineering	M.S.C.E. M.S.E.
		Mineral Processing Engineering	B.S. M.S.
		Mineral Resource Economics	M.S.
		Petroleum Engineering	B.S. M.S.

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PARTICIPATING INSTITUTIONS

STATE	INSTITUTION	PROGRAM TITLE	DEGREE(S)
WI	Marquette University Milwaukee	Environmental Engineering	B.A. B.S.
	Northland College Ashland	Environmental Studies	B.A.
	University of Wisconsin-Green Bay Green Bay	Environmental Emphasis	B.A. B.S. M.E.A.S.
	University of Wisconsin-Madison Madison	Civil and Environmental Engineering	B.S.
		Environmental Communications	M.A. M.S.
		Water Resources Management, Environmental Monitoring, Land Resources	M.S. Ph.D.
	University of Wisconsin-Milwaukee	Atmospheric and Marine Environmental Program	M.S. M.E.
WY	Casper College Casper	Water Quality Technology	A.S.
	University of Wyoming Laramie	Civil Engineering	M.S. Ph.D.

Other Programs

The following programs were included in the on-site visit process and offer training through various institutes, centers, state agencies, or college consortiums. Program descriptions can be found in the volume specified.

State	Institution	Program	Volume
FL	Florida Department of Environmental Regulation	Environmental Noise Control Training	Noise
	Miami-Dade Community College	NPDES Effluent Monitoring Training	Wastewater I
		Wastewater Treatment Plant Operations	Wastewater I
		Water Treatment Plant Operations	Potable Water I
	University of Miami School of Medicine	Pesticide Protection	Pesticides
KS	Kansas State University	Institute for Environmental Research	Composite II III Business and Industry
MI	Michigan State University	Institute of Water Research	Potable Water I
		Pesticide Research Center	Pesticides
NE	University of Mid-America	Pests, Pesticides and Pesticide Safety	Pesticides

State	Institution	Program	Volume
NJ	Princeton University	Environmental Science and Policy	Composite I
NC	U.S. Environmental Protection Agency	Air Pollution Training Institute	Air
OH	Ohio State University	Center for Lake Erie Area Research	Potable Water I
		Cooperative Extension Service Activities	Composite II and III
		Water Resources Center	Potable Water I
PA	Air Pollution Control Association	Refresher, Continuing Education Courses	Air
	University of Pittsburgh	Environmental Systems Engineering	Composite I
TN	Memphis State University	Nuclear Reactor Fundamentals	Energy
		Radiation Technician Training Course	Radiation
	Oak Ridge Associated Universities	Radiation Emergency Assistance Center/ Training Site	Radiation
		Special Training	Energy Radiation
	University of Tennessee Center For Health Sciences	Training Courses in Audiometric Orientation	Noise

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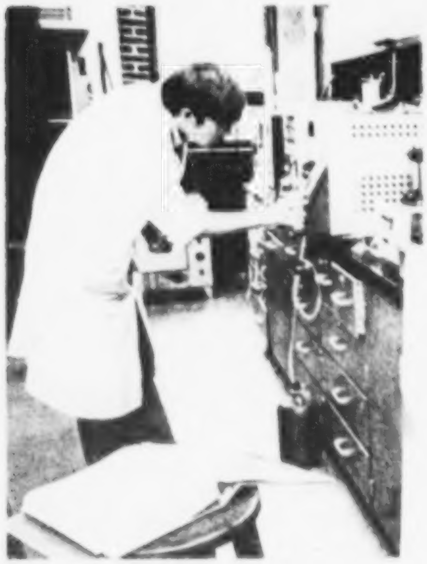
PROJECT FINDINGS



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I. A SUMMARY PROFILE OF REPRESENTATIVE ENERGY EDUCATIONAL PROGRAMS

A. States, Institutions, Programs and Degrees

Data for this portion of the National Environmental/Energy Workforce Assessment were gathered through on-site visits and follow-up correspondence with faculty and staff of colleges, universities and training institutions in forty-five states. Energy education programs offered by more than thirty schools in eighteen states were surveyed.

This report includes detailed information regarding more than forty energy programs in which ninety-five certificate or degree sequences are offered. Selection of these programs was based on a variety of factors including: information and recommendations obtained during Phase I of the project; recommendations by state, regional, and federal environmental/energy agency personnel; a review of course catalogs; and a review of other published sources of information regarding degree programs in environmental/energy areas.

On-site visits and extensive interviews were conducted to explore each of these programs in depth. Many of the institutions visited offer programs in several environmental areas. Only the energy programs are included in this volume. Table 2 lists the programs by region, state, and institution.

TABLE 2

ENERGY DEGREE PROGRAMS BY REGION, STATE, AND INSTITUTION

Region	State	Institution	Program	Degree
I	CT	Hartford State Technical College	Nuclear Engineering Technology	A.S.
	MA	Massachusetts Institute of Technology	Mineral Resources Engineering & Management	S.M. Engr. Sc.D./Ph.D.
			Nuclear Engineering	S.B. S.M. N.E. Sc.D./Ph.D.
II	NJ	Princeton University	Energy Conversion & Resources	Not Degree Granting
	NY	Columbia University	Nuclear Engineering	B.S. M.S. N.E. E.Sc.D.
		Cornell University	College Program in Energy Conversion	B.S.
			Nuclear Engineering	M.E. M.S. Ph.D.
		Polytechnic Institute of New York	Energy Engineering and Policy	Cert. M.S.w/Cert.
		Rensselaer Polytechnic Institute	Nuclear Engineering	B.S. M.S. M.E. Ph.D.

Region	State	Institution	Program	Degree
III	PA	Carnegie-Mellon University Carnegie Institute of Technology	Environmental Engineering	B.S. M.S. Ph.D.
		The Pennsylvania State University	Minerals Processing	M.S. Ph.D.
			Mining Technology	A.A.S.
			Mining Engineering	B.S. M.S. M.E. Ph.D.
			Nuclear Engineering	B.S. M.S. M.E. Ph.D.
			Nuclear Engineering Technology	A.S.
			Petroleum and Natural Gas Engineering	B.S. M.S. Ph.D.
		University of Pennsylvania	Energy Engineering	M.S.
			Energy Management & Policy	M.S. Ph.D.
	WV	Bluefield State College	Mining Engineering Technology	A.S. B.S.
		West Virginia Institute of Technology	Mining Engineering Technology	A.S.E.M.T. B.E.M.T.
		West Virginia University	Engineering of Mines	B.S. M.S.
			Mineral Processing Engineering	B.S. M.S.

Region	State	Institution	Program	Degree
		West Virginia University (cont'd)	Mineral Resource Economics	M.S.
			Petroleum Engineering	B.S. M.S.
IV	FL	University of Florida	Nuclear Engineering	B.S. B.S.E. M.S. M.E. Ph.D. Engr.
	GA	Georgia Institute of Technology	Energy Engineering	Adv. Cert.
		Southern Technical Institute	Nuclear Safety	A.S.
	KY	Morehead State University	Mining Technology	A.A.S.
		Pikeville College	Mining Technology	A.M.T.
		University of Kentucky	Energy (Coal) Engineering	M.S. Ph.D.
	TN	University of Tennessee	Nuclear Engineering	B.S. M.E. M.S. Ph.D.
V	IN	Purdue University	Nuclear Engineering	B.S.N.E. M.S. Ph.D.
	OH	Muskingum Area Technical College	Petroleum Engineering Technology	A.A.S.
VI	NM	University of New Mexico	Nuclear Engineering	M.S. Ph.D.
	TX	Lamar University	Energy Resources Management	B.S.

Region	State	Institution	Program	Degree
		Texas State Technical Institute	Nuclear Systems Technology	A.A.S.
VII	KS	Kansas State University	Chemical Engineering	B.S. M.S. Ph.D.
			Nuclear Engineering	B.S. M.S. Ph.D.
VIII	UT	Brigham Young University	Chemical Engineering Energy and Environment	B.S. M.S. Ph.D.
IX	CA	University of California - Berkeley	Nuclear Engineering	B.S. M.S. M.S.Eng.Sci. M.E. Ph.D.
X	OR	Oregon State University	Nuclear Engineering Technology	B.S.
			Nuclear Engineering	B.S. M.S.

As Table 2 indicates, 10 schools offer associate degrees; 17 offer bachelors; 17 offer one or more masters degree; 3 offer a professional degree; and 16 offer a Doctor of Philosophy and/or a Doctor of Science degree. The Polytechnic Institute of New York offers a certificate as a concentration within masters programs available through several departments.

B. Enrollment Statistics and Graduates

Because of the extremely diverse nature of the energy educational programs included in this report there are few characteristics held in common throughout. Enrollments vary from fewer than ten to more than six hundred. Nearly 60% of the students are in bachelors programs; of these, 99.5% are full-time students. Associate degree programs account for slightly more than 25% of all students; nearly three-quarters of these students are full-time. Part-time students in these programs often hold full-time jobs, especially in mining technology programs. Approximately 13% of the students are enrolled in masters programs; of these only two-thirds are full-time. It is at this level that many students are employed full-time and have returned to school to enhance their opportunities for advancement or to qualify for a job significantly different from that presently held. Doctor of Philosophy and Doctor of Science degree candidates account for little more than 3% of the enrollments discussed in this report; nearly 90% are enrolled full-time. Of those who are listed as part-time, most have completed all course work and are working on dissertations; many of these are employed full-time. Fewer than five percent of the students in the energy education programs surveyed are women.

The following table summarizes the enrollment profiles of the energy degree programs surveyed during Phase II. The reader should keep in mind these facts when reviewing this table:

1) These figures do not include all energy degree programs in the country;

2) In cases where breakdowns between master's and doctoral programs are unavailable within any one program, each doctoral degree was assumed to comprise ten percent of the total figure;

3) The enrollment change (up/down/stable) indicates apparent enrollment trends over the last three years. Each degree receives one response.

TABLE 3
ENERGY ENROLLMENT PROFILE SUMMARY
(REGIONS I through X)

Degree	Enrollment Full-time	Enrollment Part-time	Graduates Average # Per Year	Enrollment Change by Program Up	Down	Stable
Associate	774	265	260	6	3	1
Bachelors	2,540	19	503	11	0	7*
Masters	503	199*	211	15	0	12
Doctoral	171	24	39	3	0	11
Graduate[1]	165	0	70	3		
Certificate (Masters Level)	6	50	30	1		
TOTAL	4,159	557	1,113	39	3	31

*Complete figures are not available

[1] No breakdown among graduate students was available for some programs

Of special significance is the overall enrollment trend. Higher education, as a whole, is experiencing a time of steady or declining enrollment. The energy field is more than holding its own. Four of the five mining technology associate degree programs reported increasing enrollments; one has declined. Half of the B.S. programs reported stable enrollments; half reported increases. Twenty masters programs have increasing enrollments; 12 are stable; 3 did not reply to this question. Eight doctoral programs noted an increase in enrollment; ten are stable.

Overall, approximately 88% of the students are full-time; 12% part-time. More than half of the part-time students (nearly 60%) are at the associate level; many are miners. More than a third of the part-time students are masters degree candidates. B.S. and Ph.D. students account for less than one percent of the part-time enrollment. With only one program (at the associate level) indicating a decline in enrollment and the remainder nearly equally divided between stable and increasing enrollments, as a whole, energy education enrollments are increasing.

C. Student Origin

The ratio of in-state to out-of-state and foreign student enrollment varies greatly as depicted in Table 9. Among the associate degree programs, 80 to 100% of the students are in-state; none are foreign. Among the bachelors programs, one reported 98% in-state enrollment, one only 33% in-state; most ranged from 70-80%. Four schools noted foreign enrollment ranging from 5% to 30%. Masters enrollments varied from a high of 75% in-state to a low of 20%. Most reported 50% or less. About half have foreign students, varying from 5% to 50%. Ph.D. enrollment ratios are similar to the masters. Several schools indicated that foreign applications to their programs are extremely heavy.

D. Employment

As indicated in Table 9 under Employment, 90-100% of the graduates of associate degree programs obtain jobs in private industry. Graduates include petroleum and nuclear safety technicians; most are coal miners. Bachelor degree holders, for the most part, find jobs in industry (90-100%). Those programs indicating exceptions to this ratio include five nuclear engineering and one environmental engineering program. No pattern emerges as to the distribution of graduates not entering industry. No general statement is appropriate to the employment of masters or Ph.D. graduates. Programs report from 20% to 95%

working in industry; from 10% to 60% in government; as many as 30% in consulting. The following table presents employment data:

TABLE 4

ENERGY EMPLOYMENT PROFILE

	PRIVATE SECTOR				
DEGREE	Industry/	Combined*/	Consulting	GOVERNMENT	OTHER
Associate	81%	8%		7%	4%
Bachelors	56%	8%	12%	18%	6%
Masters	55%	8%	9%	26%	2%
Nuclear Engineer	64%			18%	18%
Doctoral	21%	3%	9%	38%	29%
Graduate[1]			52%	48%	
Certificate	50%		45%	5%	

[1] Some programs were unable to break out Masters and Doctoral students.

* Some programs were unable to break private sector employment into separate categories of industry/consulting.

The data depicted in Table 4 were compiled for each degree level by utilizing the average annual graduates figures within each program, and obtaining employment figures in real numbers. These real numbers for each program were then totaled and reworked into total percentages.

A discussion of specific occupations which graduates of these programs enter, in the public and private sectors, may be found in The additional Findings (E. Energy Occupations) of this report.

E. Faculty

The diversity represented by these programs is reflected in the staffing configurations. Altogether, 231 full-time (58%) and 165 part-time (42%) faculty were recorded. Three patterns of staffing are readily identifiable. Approximately half of the programs rely exclusively or nearly so on full-time program faculty. Several programs are made up of a core program faculty supplemented by several people who are cost-centered in other departments. The arrangement may involve a specified proportion of time devoted to the program or maybe as limited as offering one course in alternate years. The third method of staffing is practiced by multidisciplinary efforts which often do not lead to separate degrees, but frequently to a special concentration or certificate. Often one person is responsible for coordination of contributive efforts of faculty from many departments who are listed as part-time with regard to the energy program. The contribution of these faculty members may range from active participation in program administration, student advising, and curriculum decisions to assuming the responsibility for teaching a single course infrequently.

No meaningful student-faculty ratio can be developed due to the variance in methods of program staffing and because of differences in teaching loads and research commitments.

F. Internship/Applied Study Terms

Several programs indicated internships or applied study terms are an integral component of the educational experience. Seven of the associate programs either require or contain an active option of internships; 13 of the bachelors programs do so; as do nine of the masters programs. It is an option in a few doctoral programs.

Several respondents singled out the applied study aspect as the most important component distinguishing their program from similar efforts. Some, particularly at the associate level, indicated that such experience is essential to the development of a well-qualified graduate. Many, especially at the bachelor level, noted that their graduates who have participated in an internship or applied study term have a measurable advantage in the job market over people who have no practical experience. Most programs boasted examples of students who, upon graduation, had been offered full-time positions with the firm or agency with which they had interned.

G. Graduate Follow-Up

Very few programs have graduate follow-up data beyond entry level for more than a small number of individuals who have maintained personal contacts with faculty members. Many of the programs which replied in the affirmative to graduate follow-up were quick to state that it was on an informal basis. Those with formal follow-up procedures depend heavily upon program or department mail surveys.

II. ADDITIONAL FINDINGS

A. Recruitment Techniques

Only one program respondent said recruitment was a major problem. Most said their recruitment efforts are adequate and several (particularly mining technology and nuclear technology and engineering programs) replied they, as a program, did no active recruitment because student demand is high in response to high paying jobs awaiting graduates. Many programs, especially at the undergraduate level depend primarily or wholly upon university-wide recruiting programs.

The most common means of alerting potential students as to the existence of a program and its emphases and offerings is the descriptive brochure. These, often accompanied by a poster, are mailed to high schools and undergraduate departments. Frequently a return card is attached to or incorporated in the brochure to facilitate requests for further information. Department faculty on university recruitment personnel usually distribute brochures to students during high school career opportunities events.

Other recruiting aids or processess specifically mentioned were:

1) Word of mouth - especially among graduate programs. Some referred to "general school/department reputation".
2) Financial Aid/Scholarships - the availability of support money is considered by several programs to be a significant factor in recruiting efforts.

3) Referrals by employers - coal companies, in particular, often recommend personnel or potential personnel attend a specific school or program.

4) Answering inquiries - quick, detailed response to information requests is deemed by many to be very important. Most rely on form letters and a prepared packet. Smaller programs make a point of drafting personal replies.

B. Research Funding and Sources of Student Support

The topical, pervasive, and critical aspects of the energy education field are evidenced by the degree and widespread sources of research support. As would be expected, the U.S. Department of Energy is the most prevalent source of research money. Other federal sources include the U.S. Bureau of Mines; the Environmental Protection Agency; Health, Education, and Welfare; and the Nuclear Regulatory Commission. Many state agencies support projects.

The National Science Foundation is a major funding source, as is the Ford Foundation. Many industries, especially through institute contributions, support a variety of research. The Electric Power Research Institute and the American Iron and Steel Institute are large funding sources. Oil and gas companies and utilities support several research programs. Others noted were the Appalachian Regional Commission and the National Institute of Health. One program specifically mentioned a project with foreign support.

Student support includes several sources and types traditionally available to people regardless of major and some which are unique or of more than usual significance to energy education.

University-wide scholarships are quite common, as are student loans. Most energy program students are employed during the summer and many work during the school year; the work-study program is a common source of income. Research and teaching assistantships are available in most graduate programs. Many student jobs are supported through research funding.

Engineering students are often eligible for a cooperative work program. Many students have industry grant support, often in the form of a traineeship. Many, especially in the associate programs, qualify for Basic Educational Opportunity Grants. Some students receive support from professional societies; some are reimbursed for their education expenses by their employer.

Fellowships are common. Industry and the Department of Energy are major sources of fellowship monies; some are available through private endowment. No program respondent mentioned G.I. benefits as a major source of support. This may be an accurate reflection of the situation or it may be an oversight enhanced by discussing the question with faculty rather than students.

C. Usage of ERIC and IRIS

ERIC and IRIS are federally maintained computer retrieval systems encompassing educational resource materials on a national scale. Since the effectiveness of any such system can best be measured by its application and use, Phase II was appropriately expanded to include an adjunct assessment of the "utilization profile" of the educational community.

It should be pointed out that the respondents to the assessment question, "Have you ever used ERIC or IRIS?", were faculty rather than students, and that the findings contained in Table 5 should be interpreted accordingly.

TABLE 5

ERIC/IRIS UTILIZATION PROFILE - ENERGY

	Yes	No	Total Responding
ERIC	6	23	29
IRIS	6	23	29

It should be noted that many of the "no" responses were followed by a statement or question indicating the respondent did not know one or both of the retrieval systems existed.

Of all the environmental areas surveyed in Phase II (air, noise, pesticides, potable water, radiation, solid waste, wastewater, and energy), the following depicts the total number of responses.

TABLE 6

ERIC/IRIS UTILIZATION PROFILE - PHASE II SUMMARY

	Yes	No	Total Responding
ERIC	72	307	379
IRIS	64	314	378

D. Program Flexibility

Phase II researchers, in an effort to compile data relative to the procedural, administrative, and developmental constraints in the modification of curriculum materials, posed the following questions to faculty members that were interviewed: "What is the time required to implement a complete content change in a course?" and, "What is the time required to implement a complete change in a program?". For the purposes of this study, a program is considered a course of study, either completely prescribed, or containing options, with an identity of its own and standard rules and procedures, the satisfaction of which leads to a degree, certificate, or diploma. A course is considered a unit of a program, in which a body of knowledge is presented, the satisfactory completion of which leads to the awarding of a predetermined or individually arranged number of credits.

The questions were asked of faculty members in each of the program areas described in this review. It was believed that the compilation of such information could provide useful and informative comparisons by degree level, by geographic location, and by other related variables. It was also thought that this information would provide insights into the flexibility or lack of flexibility in the development and modification of courses and programs. This information holds potential interest to those considering the development of curricula, to those currently offering, but considering the modification of curricula, and to potential funding sources.

The following tables present categorizations of responses to the curriculum flexibility questions. Each responding program has one response recorded for each degree level. The responses are to be considered the best estimates of these faculty members of the time frames required to complete the changes under "normal" conditions.

TABLE 7

TIME REQUIRED TO IMPLEMENT A COMPLETE CONTENT CHANGE IN A COURSE

Degree Program	Less than 1 month	1 month-1 year	more than 1 year; less than 2	2-4 years	more than 4 years	Undetermined
Associate	1	7				1
Bachelors	3	13	3			
Masters	5	16	2			1
Doctoral	4	11	1			1
TOTAL	13	47	6			3

Most energy education programs are able to implement a new course in a few months, usually for the upcoming semester or quarter. Thirteen answered that they could initiate a new course immediately. Several noted that a change at the graduate level is easier to implement than at the bachelors level.

TABLE 8

TIME REQUIRED TO IMPLEMENT A CONTENT CHANGE IN A PROGRAM SEQUENCE

Degree Program	Less than 1 month	1 month-1 year	more than 1 year; less than 2	2-4 years	more than 4 years	Undetermined
Associate	1	6	2			1
Bachelors		14	1	2	1	
Masters	2	16	2	3		1
Doctoral	1	10	2	2		1
TOTAL	4	46	7	7	1	3

Most changes in program curriculum, requirements, and sequences are possible in less than a year's time. A few programs can implement changes immediately, some take slightly more than a year, and some are subject to a extensive review process which takes three to four years. As with single course changes, faculty noted that it is a simpler process to change graduate rather than undergraduate programs.

E. Energy Occupations

Preparation of students for specific occupations or for a general occupational area was discussed during interviews. To verify data and maintain consistency, respondents were mailed occupational check lists specific to their program area(s). They were asked to indicate those occupations listed for which their graduates are qualified and to add appropriate occupations not listed. The following is a summary of the results of the occupational portion of the study.

The Associate level programs included in this energy volume are of three basic types: Mining Technology, Petroleum Technology, and Nuclear Engineering/Safety Technology. Graduates are prepared for the following occupations:

Entry Level Miner (Coal)
Petroleum Engineer Technician
Industrial Radiologist
Radio-Chemistry Technician
Health Physics Technician
Property Analysis Technician (Petroleum)
Reactor Operator
Research Assistant
Air Pollution Control Technician
Environmental Tester/Analyst
Drilling Technician
Physical Science Technician

Bachelors level programs discussed prepare students for the following occupations:

Chemical Engineer
Electrical Engineer
Energy Efficiency Technician
Energy Engineer
Geophysicist
Mechanical Engineer
Metallurgist
Mineralogist
Mineral Processing Engineer
Mining Engineer
Mining Geologist
Nuclear Engineer
Nuclear Technician
Petroleum Engineer
Petroleum Geologist
Physicist
Power Reactor Operator
Agronomist
Bacteriologist
Biochemist
Biophysicist
Chemist
Ecologist
Environmental Control Technologist
Nuclear Plant Operator
Strip Mine Inspector
Solar Energy Technician
Resource Conversion Technician
Industrial Engineer
Safety Engineer
Petroleum Geologist Technician

Graduate level programs prepare people for the above occupations and, in addition, the following:

Environmental Physicist
Mechanical Engineer (Conversion)
Energy Policy Analyst
Environmental Monitor Specialist
Environmental Science Technician
NRC License and Standards
Electric Power Engineer
Energy Management Systems Analyst
Industrial Hygienist
Oceanographer
NRC Inspector

Employment opportunities for graduates entering most of the above occupations are very good. Most have several job offers or move into a position for which they have made specific preparation. The job market for women and minorities in most of these occupations is extremely good.

F. Images of Energy Programs Within The Institution

The image of energy programs within the institution as reflected by attitudes of colleagues and other students is highly favorable. No program reported any difficulties in this regard. The energy programs which are a part of or an outgrowth of an established engineering program generally enjoy the same reputation as the parent department.

G. The Need For Additional Curriculum Materials

The need for additional curriculum materials was of little concern to all but the persons interviewed representing the Associate level. Finding a happy medium appears to be the goal. Existing materials are often too narrowly focused or too broad; the reading and/or technical level is commonly too high or beneath the students' level.

H. Student/Graduate Communication And Management Skills

During Phase I of the National Environmental/Energy Workforce Assessment, researchers noted that a large number of the persons interviewed who employ persons with environmental or energy training/education observed that many graduates are being produced who are deficient in the much needed communication (oral and written) and financial management skills. During Phase II, faculty of the environmental/energy programs were questioned regarding their own attitudes on this subject in order to ascertain the consistencies or discrepancies in perceptions between academia and prospective employers of graduates.

Respondents in engineering-based programs generally agreed that communication skills are a problem with students entering the programs. These programs attempt to deal with the problem by such means as requiring students to prepare technical reports and participate in oral presentations within specific courses, and by encouraging or requiring the development of a thesis or dissertation. The efforts to enhance student communication skills within engineering programs are often limited. The reasons for this include: a) communication courses that may be chosen as electives are rarely geared toward the specific needs or purposes of engineering; and b) some engineering programs have been under pressure to reduce the number of credits required for a degree, and as few engineering courses can be deleted, those courses such as technical report writing must often be eliminated from the curriculum.

A similar, though slightly less emphatic, response was elicited from engineering faculty regarding student/graduate financial management skills. Within most engineering departments, courses are available that deal directly and/or indirectly with engineering economy and financial management.

Faculty teaching in associate programs who responded to the question felt the level of communication skills is a common and major difficulty affecting their presentation of material and evaluation of the learning process through means other than hands-on demonstration and practice.

Respondents from other programs replied that the skills levels in communication and financial management vary greatly from student to student. Most attempt to deal with the problems by advising students in need of upgrading to take appropriate electives or to avail themselves of the services of special tutoring centers which are free and open to all students on many campuses.

III

A Summary Profile of Representative Educational Programs

The following footnotes (1-6) refer to the various column headings of the Table. Other footnotes are specific to the figures which were provided by various institutions and are used throughout the Table.

[1]Enrollment	1976-77 statistics
[2]Graduates	average for last three years; 'change' indicated apparent trends within that three-year period
[3]Employment	'other' includes positions such as those found within the educational community
[4]Faculty	full-time and part-time is determined by individual institutions
[5]Internship/Applied Study	part of an option to obtain a degree; may or may not have financial reimbursement connected with it
[6]Graduate Follow-up	a standardized procedure that enables the institution to periodically determine the employment of their graduates
NA	Not Applicable/Not Available
*Asterisk	denotes that a program appears in more than one volume of the profile

TABLE

A SUMMARY PROFILE OF REPRESENTATIVE

STATE	INSTITUTION	PROGRAM	DEGREE	ENROLLMENT[1]		GRADUATES[2]	
				FULL TIME	PART TIME	No. / YEAR	CHANGE
CA	University of California - Berkeley	Nuclear Engineering	B.S.	120		86	Up
			M.S.	22		15	Stable
			M.S.E.S.	22		14	Stable
			M.E.	2		1	Stable
			Ph.D.	43		9	Stable
CT	Hartford State Technical College	*Nuclear Engineering Technology	A.S.	12	0	10	Down
FL	University of Florida	Nuclear Engineering	B.S.	119		35	Up
			B.S.E.				Up
			M.S.	31	20	24	Up
			M.E.				Up
			Ph.D.	20		3	Up
			Engr.	0		0	Stable
GA	Georgia Institute of Technology	Energy Engineering	Adv. Cert.	N/A	N/A	3	Stable
	Southern Technical Institute	*Nuclear Safety	A.S.	10	0	0	Down
IN	Purdue University	Nuclear Engineering	B.S.N.E.	90	N/A	N/A	N/A
			M.S.	21	N/A	14	Up
			Ph.D.	16	N/A	4	Up

9

ENERGY EDUCATIONAL PROGRAMS

STUDENT ORIGIN IN-STATE/ OUT-OF-STATE/ FOREIGN (%)	EMPLOYMENT PRIVATE SECTOR INDUSTRY	CONSULTING	GOV'T	OTHER[3]	FACULTY[4] FULL TIME	PART TIME	INTERNSHIP/[5] APPLIED STUDY YES	NO	GRADUATE[6] FOLLOW-UP YES	NO
60/10/30	50%	30%	20%		12	0	X			X
20/40/40	20%	10%	50%	20%				X		X
20/40/40	20%	10%	50%	20%				X		X
20/40/40	20%	10%	50%	20%				X		X
20/40/40	20%	10%	50%	20%				X		X
100/NA/NA	70%		30%		1	0	X		X	
84/5/11	N/A	N/A	N/A	40%	11	1	X			X
84/5/11	N/A	N/A	N/A							
33/56/10	N/A	N/A	N/A							
33/56/10	N/A	N/A	N/A	N/A			X			X
33/56/10	N/A	N/A	N/A				X			X
NA/NA/NA	N/A	N/A	N/A	N/A			X			X
NA/NA/NA	N/A	N/A	N/A	N/A	0	11		X		X
80/20/NA	N/A	N/A	N/A	N/A	1	0		X	X	
65/30/5	30%	30%	10%	30%	10	0	X			X
45/30/25	26%	12%	21%	41%						
45/30/25		14%	72%	14%						

TABLE

A SUMMARY PROFILE OF REPRESENTATIVE

				ENROLLMENT[1]		GRADUATES [2]	
STATE	INSTITUTION	PROGRAM	DEGREE	FULL TIME	PART TIME	No. / YEAR	CHANGE
KS	Kansas State University	*Chemical Engineering	B.S.	180	0	35	N/A
			M.S.	12	0	4	Stable
			Ph.D.	10	0	2	Stable
		Nuclear Engineering	B.S.	100	0	17	Stable
			M.S.	13	2	5	Stable
			Ph.D.	9	1	3	Stable
KY	Morehead State University	Mining Technology	A.A.S.	79	0	15	UP
	Pikeville College	Mining Technology	A.M.T.	131	0	65	Up
	University of Kentucky	Energy (Coal) & Engineering	M.S.	8	0	3	Up
			Ph.D.	2	0		Up
MA	Massachusetts Institute of Technology	Mineral Resources Engineering & Management	S.M.	15	N/A	N/A	N/A
			Engr.		N/A	N/A	N/A
			Sc.D./Ph.D.		N/A	N/A	N/A
		*Nuclear Engineering	S.B.	30	0	N/A	N/A
			S.M.	150	0	39	Up
			N.E.		0	7	Up
			Sc.D./Ph.D		0	24	Up
NJ	Princeton University	Energy Conversion & Resources	Not Degree Granting	N/A	N/A	N/A	N/A
NM	University of New Mexico	Nuclear Engineering	M.S.	10	11	12	Stable
			Ph.D.	10	15	3	Stable

9

ENERGY EDUCATIONAL PROGRAMS

STUDENT ORIGIN IN-STATE/ OUT-OF-STATE/ FOREIGN (%)	EMPLOYMENT				FACULTY[4]		INTERNSHIP/[5] APPLIED STUDY		GRADUATE[6] FOLLOW-UP	
	PRIVATE SECTOR INDUSTRY	PRIVATE SECTOR CONSULTING	GOV'T	OTHER[3]	FULL TIME	PART TIME	YES	NO	YES	NO
NA/NA/NA	70%	N/A	10%	20%	11	0		X	X	
NA/NA/NA	70%	N/A	10%	20%				X	X	
NA/NA/NA	50%	10%	10%	20%				X	X	
70/30/NA	22%	22%	10%	45%	8	2	X		X	
70/30/NA	22%	45%	10%	22%				X	X	
70/30/NA	23%	23%	10%	44%				X	X	
97/3/NA	100%				1	13		X		X
90/10/NA	90%			10%	5	6	X		X	
60/40/NA	57%	3%	17%	11%	10	0	X		X	
60/40/NA	57%	3%	17%	11%			X		X	
NA/NA/10	N/A	N/A	N/A	N/A	0	20		X		X
NA/NA/10	N/A	N/A	N/A	N/A						
NA/NA/10	N/A	N/A	N/A	N/A						
NA/NA/33	N/A	N/A	N/A	N/A	25	0	X			X
NA/NA/33	15%	5%	30%	50%			X			X
NA/NA/33	64%		18%	18%			X			X
NA/NA/33	3%	6%	36%	55%			X			X
20/60/20	50%		50%		0	12		X		X
25/65/10	75%	20%	5%		8	0		X		X
25/65/10	75%	20%	5%					X		X

TABLE

A SUMMARY PROFILE OF REPRESENTATIVE

STATE	INSTITUTION	PROGRAM	DEGREE	ENROLLMENT[1]		GRADUATES[2]	
				FULL TIME	PART TIME	No. / YEAR	CHANGE
NY	Columbia University	*Nuclear Engineering	B.S.	35	0	15	Stable
			M.S.	25	15	15	Stable
			N.E.			1-2	Stable
			E.Sc.D.			2-3	Stable
	Cornell University	College Program in Energy Conversion	B.S.	5	0	2	Stable
		*Nuclear Engineering	M.E.	6	0	6	Stable
			M.S.	1	0	1	Stable
			Ph.D.	5	0	1	Down
	Polytechnic Institute of New York	Energy Engineering and Policy	Cert.	6	50	30	Up
	Rensselaer Polytechnic Institute	*Nuclear Engineering	B.S.	115	0	30	Up
			M.S.	50	12	18	Up
			M.E.				Up
			Ph.D.	17	0	5	Up
OH	Muskingum Area Technical College	Petroleum Engineering Technology	A.A.S	19	15	9	Up
OR	Oregon State University	Nuclear Eng. Technology	B.S.	54	0	10	Stable
		Nuclear Engineering	B.S.	106	0	20	Stable
			M.S.	28	0	5	Stable
			Ph.D.	(New Program)			
PA	Carnegie-Mellon University Carnegie Institute of Technology	*Environmental Engineering	B.S.	120	0	34	Up
			M.S.	20	0	19	Up
			M.E.		0		Up
			Ph.D.	8	0	1	Stable

ENERGY EDUCATIONAL PROGRAMS

STUDENT ORIGIN IN-STATE/ OUT-OF-STATE/ FOREIGN (%)	EMPLOYMENT				FACULTY[4]		INTERNSHIP/[5] APPLIED STUDY		GRADUATE[6] FOLLOW-UP	
	PRIVATE SECTOR									
	INDUSTRY	CONSULTING	GOV'T	OTHER[3]	FULL TIME	PART TIME	YES	NO	YES	NO
NA/NA/NA	N/A	75%	25%		7	0		X		X
NA/NA/NA	N/A	30%	60%	10%				X		X
NA/NA/NA	N/A	30%	60%	10%				X		X
NA/NA/NA	N/A	30%	60%	10%				X		X
NA/NA/NA	N/A	N/A	N/A	N/A	0	6	X			X
NA/NA/NA	N/A	N/A	N/A	N/A	3	5		X		X
NA/NA/NA	N/A	N/A	N/A	N/A				X		X
NA/NA/NA	N/A	N/A	N/A	N/A				X		X
NA/NA/50	50%	45%	5%		0	12	X			X
NA/NA/NA	30%	10%	60%		11	6		X	X	
NA/NA/NA	30%	10%	60%					X	X	
NA/NA/NA	30%	10%	60%					X	X	
NA/NA/NA	30%	10%	60%					X	X	
99/1/NA	78%		11%	11%	1	0	X		X	
80/20/NA	60%		40%		9	0			X	X
80/20/NA	70%		30%						X	X
70/30/NA	60%	10%	20%	10%					X	X
50/50/NA	40%	30%	30%		4	2			X	X
25/62/13	40%	30%	30%						X	X
25/62/13	40%	30%	30%						X	X
25/62/13	40%	30%	30%						X	X

TABLE

A SUMMARY PROFILE OF REPRESENTATIVE

STATE	INSTITUTION	PROGRAM	DEGREE	ENROLLMENT[1]		GRADUATES[2]	
				FULL TIME	PART TIME	No. / YEAR	CHANGE
	The Pennsylvania State University	*Minerals Processing	M.S.	N/A	22	2	Up
			Ph.D.	N/A			Up
		Mining Technology	A.A.S	200	100	100	Up
		Mining Engineering	B.S.	350	0	65	Stable
			M.S.	25	0	7	Stable
			M.E.	0	0	0	Stable
			Ph.D.	9	0	2	Stable
		*Nuclear Engineering	B.S.	180	0	40	Up
			M.S.	N/A	40	18	Up
			M.E.				Up
			Ph.D.				Up
		*Nuclear Engineering Technology	A.A.S.	30	0	20	Down
		Petroleum & Natural Gas Engineering	B.S.	135	0	35	Up
			M.S.	29	0	6	Up
			Ph.D.	N/A	N/A	1	Stable
	University of Pennsylvania	Energy Engineering	M.S.E.	2	6	1	Stable
		Energy Management & Policy	M.S.	45	16	5	Up
			Ph.D.			2	Stable
TN	University of Tennessee	*Nuclear Engineering	B.S.	121	9	21	Up
			M.S.	50	0	8	Up
			M.E.		0		Up
			Ph.D.		0	5	Up
TX	Lamar University	Energy Resources Management	B.S.	30	0	8	Stable
	Texas State Technical Institute	Nuclear Systems Technology	A.A.S.	35	N/A	13	Up

ENERGY EDUCATIONAL PROGRAMS

STUDENT ORIGIN IN-STATE/ OUT-OF-STATE/ FOREIGN (%)	EMPLOYMENT				FACULTY[4]		INTERNSHIP/[5] APPLIED STUDY		GRADUATE[6] FOLLOW-UP	
	PRIVATE SECTOR INDUSTRY	CONSULTING	GOV'T	OTHER[3]	FULL TIME	PART TIME	YES	NO	YES	NO
25/38/37	80%			20%	2	1		X	X	
	80%			20%				X	X	
100/NA/NA	90%		10%		17	0	X		X	
	90%		10%				X		X	
50/30/20	90%		10%					X	X	
NA/NA/NA	N/A		N/A							
50/30/20	90%		10%					X	X	
80/20/NA	44%	23%	33%		16	0	X		X	
50/50/NA	44%	23%	33%					X	X	
50/50/NA	44%	23%	33%					X	X	
50/50/NA	44%	23%	33%					X	X	
90/10/NA	44%	23%	33%		N/A	N/A		X	X	
80/20/NA	90%		10%		7	0		X	X	
50/50/NA	90%		10%					X	X	
50/50/NA	90%		10%					X	X	
34/33/33		50%	50%		0	16		X		X
34/33/33		50%	50%		0	35	X		X	
34/33/33		50%	50%				X		X	
66/28/5	30%		10%	60%	9	0	X			X
30/55/15	15%		85%				X		X	
30/55/15							X		X	
30/55/15	32%		68%				X		X	
90/10/NA	95%		5%		4	0		X	X	
95/5/NA	90%		10%		2	0	X			X

TABLE

A SUMMARY PROFILE OF REPRESENTATIVE

STATE	INSTITUTION	PROGRAM	DEGREE	ENROLLMENT[1]		GRADUATES[2]	
				FULL TIME	PART TIME	No. / YEAR	CHANGE
UT	Brigham Young University	Chemical Engineering, Energy and Environment	B.S.	17	0	15	Stable
			M.S.	12	0	7	Stable
			Ph.D.	8	0	1	Stable
WV	Bluefield State College	Mining Engineering Technology	A.S.	103	0	10	Stable
			B.S.	10	0	N/A	N/A
	West Virginia Institute of Technology	Mining Engineering Technology	A.S.E.M.T.	155	150	18	Up
			B.E.M.T.	35	0	6	Up
	West Virginia University	Engineering of Mines	B.S.	438	N/A	55	Up
			M.S.	33	62	11	Up
		Mineral Processing Engineering	B.S.	18	N/A	6	Up
			M.S.	25	N/A	1	Up
		Mineral Resource Economics	M.S.	11	N/A	5	Up
		Petroleum Engineering	B.S.	142	N/A	12	Up
			M.S.	10	N/A	7	Up

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ENERGY EDUCATIONAL PROGRAMS

STUDENT ORIGIN IN-STATE/ OUT-OF-STATE/ FOREIGN (%)	EMPLOYMENT PRIVATE SECTOR		EMPLOYMENT		FACULTY[4]		INTERNSHIP/[5] APPLIED STUDY		GRADUATE[6] FOLLOW-UP	
	INDUSTRY	CONSULTING	GOV'T	OTHER[3]	FULL TIME	PART TIME	YES	NO	YES	NO
50/50/NA	95%		5%		6	6		X		X
50/50/NA	95%		5%					X		X
50/50/NA	85%	10%		5%				X		X
95/5/NA	100%				2	4	X			X
95/5/NA	100%						X			X
95/5/NA	100%				4	7	X			X
95/5/NA	100%						X			X
33/67/NA	95%		5%		12	0	X		X	
33/67/NA	95%		5%				X		X	
33/67/NA	95%		5%		4	0	X		X	
33/67/NA	95%		5%				X		X	
33/67/NA	95%		5%		4	0	X		X	
33/67/NA	95%		5%		4	0	X		X	
33/67/NA	95%		5%				X		X	

Photo reprinted from the
Michigan Technological
University Catalog 1975-76

PROJECT COMMENTARY

Photo reprinted from the
University of Missouri,
Columbia Bulletin 1977

PROJECT CONSTRAINTS

In preparation for the on-site interviews, all of the institutions' catalogs were intensively reviewed in order to determine where environmental programs were being offered. During the course of this study, 171 institutions were visited and a total of 338 environmental programs, representing 45 states and Washington, D.C., were surveyed in detail. Albeit significant, these programs represent only a portion of all such programs available and cannot be construed as an in-depth survey of all environmental programs. It is, however, a representative sample within each of the environmental pollution control areas of Air, Noise, Pesticides, Radiation, Water and Wastewater, Solid Waste and Energy.

Several constraining factors to the proposed comprehensiveness of the study were encountered while collecting data from the institutions. It was disappointing to find that definitive records or statistics which would describe the placement of environmental program graduates specifically were typically unavailable. General indications of placement within categories, such as government or industry, were often available in percentages only. Depending on the size of the program and its age, some contact people could describe all graduates, others knew only where the past year's graduates were presently employed, and still others were aware only of their advisees' entry-level positions and subsequent moves.

It also became clear during the on-site interviews that some programs of similar or identical content had different titles. This lack of clarity within the environmental areas serves to confuse the casual reader. For that reason, attention must be directed to the actual environmental course listings included in each program summary.

A list of terms commonly used during the on-site interviews and subsequently in this report was developed in order to facilitate precise data gathering. The reader is directed to Appendix II, TERMINOLOGY.

No attempt was made, in this report, to qualitatively judge any of these programs. The apparent absence of substantial qualitative measures in the environmental education field in general and the desire to collect data in a neutral atmosphere underscore the reasons for this omission. It appears that there is a need for the development of an environmental program model in each of these areas in order that some qualitative standards be provided where none now exist.

PROJECT COMMENTARY

The overall picture of the energy education field is that of a healthy, productive, successful area. Few programs have difficulty in attracting students or placing graduates. Increasing public awareness of and interest in energy matters is having the anticipated positive effect upon these programs.

Upon closer inspection, however, some disparate aspects present themselves. The nuclear engineering programs, for example, offered mixed appraisals of current and future conditions. Some noted that the nuclear program on campus has become more accepted among the general student body. It is thought that this may be a reflection of the attitude of the general public, thus indicating that public opposition to nuclear power plants may be on the wane and that the current slow down on power plant construction may be overcome with a resulting increase in jobs in the field. Others were not so optimistic and felt that demand for graduates would remain stable. Still others contended that employment potential for graduates in this field is growing steadily and has not suffered in the recent past.

Schools in major coal mining areas (particularly West Virginia and Pennsylvania) noted hostility toward anything or anyone dubbed "environmental" because of perceived threats to job availability and security. The major industry support offered students and programs may promote this attitude.

Most respondents felt that energy programs will continue to grow and to proliferate. Most anticipate substantially increased funding (especially government and industry supported research). Others expressed a more cautious opinion based on feelings that increased support might be of a very selective nature influenced by economic factors beyond prediction at this time.

Many observed that energy education is becoming increasingly technical in emphasis and will continue to do so. Some viewed energy management and analysis as among the most crucially needed areas in the near future and, thus, most promising for employment opportunities. Others noted that programs with teaching and research commitment to alternative energy sources and technology are only now coming into their own. Feelings were mixed as to the future funding for such programs.

Essentially, the future looks bright for energy programs, as a whole. Specific program future may be dependent upon general public attitudes, unanticipated economic factors, and national energy policy decisions.

Graduates of energy programs generally have highly sought after skills and have little difficulty finding employment. This condition is expected to continue and improve even as enrollments and subsequent graduates increase, simply because energy related expertise is in great demand.

LIST OF ENERGY TRAINING INSTITUTIONS BY DEGREE

Photo reprinted from the Michigan Technological University Catalog 1975-76

LIST OF ENERGY TRAINING INSTITUTIONS BY DEGREE

CERTIFICATE

Georgia Institute of Technology (graduate level work)
Memphis State University (certificate of completion)
Oak Ridge Associated Universities (certificate of participation)
Polytechnic Institute of New York (graduate level work)

ASSOCIATE

Hartford State Technical College
Morehead State University
Muskingum Area Technical College
Pikeville College
Southern Technical Institute
Texas State Technical Institute

BACHELORS

Lamar University

MULTIPLE DEGREES OFFERED BY ONE INSTITUTION

Associate/Bachelors:
  Bluefield State College
  West Virginia Institute of Technology

Bachelors/Masters
  West Virginia Institute of Technology

Bachelors/Masters
  West Virginia University

Associate/Bachelors/Masters/Doctorate
  The Pennsylvania State University

Bachelors/Masters/Doctorate
  Brigham Young University
  Carnegie-Mellon University
  Columbia University
  Cornell University
  Kansas State University
  Massachusetts Institute of Technology
  Oregon State University
  Purdue University
  Rensselaer Polytechnic Institute
  University of California-Berkeley
  University of Florida
  University of Tennessee

MULTIPLE DEGREES OFFERED BY ONE INSTITUTION (cont'd)

Masters/Doctorate
- University of Kentucky
- University of Pennsylvania

NON-DEGREE PROGRAMS

- Princeton University
- The Ohio State University

ENERGY
TRAINING SUMMARIES

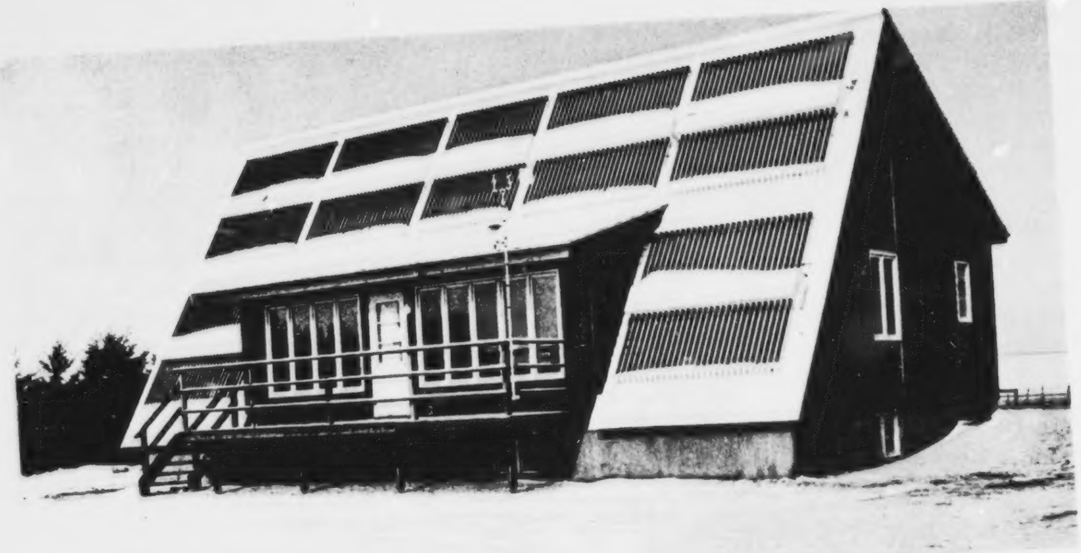

Photo reprinted from the 1976-77 Annual Report, Engineering Experiment Station, College of Engineering, University of Wisconsin, Madison

ENERGY TRAINING SUMMARIES

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INSTITUTION: BLUEFIELD STATE COLLEGE

PROGRAM: Mining Engineering Technology

DEPARTMENT: Engineering Technology

DEGREE: Associate of Science (A.S.)
Bachelor of Science (M.S.)

CONTACT: David C. Klingensmith
Director of Engineering Technology
Bluefield State College
Bluefield, West Virginia 24701
(304) 325-7102

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Bluefield State College offers both an Associate and a Bachelor's degree in mining engineering technology. Both programs are regarded as terminal but students can proceed into the B.S. program upon completion of requirements for the A.S. degree.

The Associate program began in 1968 to prepare students for occupations in the area's principal industry, coal mining. The Bachelor's program was initiated in 1977. An A.S. degree will prepare students for positions in mining such as mine draftsman, engineering aide, production planner, and preparation analyst. A B.S. degree, along with some work experience will generally prepare students for supervisory positions in areas like mine safety, labor relations, training, planning and mine operation.

PROGRAM REQUIREMENTS

Admission to the program is open to anyone with a high school diploma or the equivalent, or who is at least eighteen years of age and able to benefit from the program.

There are seventy-two semester hours of credit required for the A.S. degree and include such subjects as engineering drafting, technical physics, technical math, composition, and three hours of a socio-humanistic elective. The B.S. degree requires an additional sixty-two semester credits beyond the A.S. degree. Courses include business law, technical calculus, technical writing, principles of management, ecology, environmental control and fifteen credit hours of electives.

CURRENT FACULTY, STUDENTS, GRADUATES

Two full-time and six part-time faculty members conduct the program and devote all time to teaching.

There are currently one hundred and three full-time students in the A.S. program and ten full-time in the B.S. program. Approximately ninety-five percent of the students are from West Virginia and several career change students are attracted to the program. No formal recruitment of students is done, sicne the program generally has more applicants than it can accept.

Approximately ten students per year graduate from the A.S. program and this figure has remained stable. No figures are available for the B.S. program, which just began in 1977. Students generally find employment through faculty contacts and the college placement office. Virtually all graduates are employed in the private sector by the coal industry.

PROGRAM PROJECTIONS

Because the mining engineering technology program was just recently expanded to include a B.S. degree, no further program expansion is anticipated at this time.

COURSE DESCRIPTION

(the following is a partial listing of courses)

103 Geology of Coal - A study of the earth, forces of the atmosphere, rain, water, ice, racks of the earth, historical geology, origin of coal, structural features, coal calssification and coal resources. (1 s.h.)

205 Mine Safety and Mining Laws - A study of the various health and safety hazards encountered in the mining industry. (2 s.h.)

208 Mine Supervision - Interrelationship between the various levels of differing mining organization is presented with special emphasis on unique management problems encountered in the mining industry. (2 s.h.)

306 Environmental Controls - A study of EPA rules and regulations related to mine air, noise, pollution, and land reclamation. (2 s.h.)

402 Mine Safety Technology - Study is made of how to train and develop safe working attitudes in people. (2 s.h.)

300 Ecology - A study of the relationships between organisms and the physical and biotic environment. Field work emphasizes the local area. (2 s.h.)

INSTITUTION: BRIGHAM YOUNG UNIVERSITY

PROGRAM: Chemical Engineering, Energy and Environment

DEPARTMENT: Chemical Engineering

DEGREE: Bachelor of Science (B.S.), Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) in Chemical Engineering

CONTACT:
Dr. Calvin H. Bartholomew
Associate Professor
Chemical Engineering
Brigham Young University
Provo, Utah 84602
(801) 374-1211

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The degree programs in chemical engineering, energy and environment option, were established at Brigham Young University in 1973. As stated in the BYU catalogue, the program "...provides an ideal background for students interested in technical energy and environment problems such as coal gasification, shale oil recovery, and pollution control."

The primary emphasis of these degree programs is on chemical engineering, but students are able to choose from a variety of technical options, such as the energy and environment option. The programs are conducted through the College of Engineering Sciences and Technology, and were established in response to the pollution control and abatement needs of the energy related areas of air and water quality.

Although the students, graduating at the baccalaureate level, find few obstacles to employment in the field, approximately 50 percent pursue advanced degrees. Energy related occupations which are accessible to students upon completion of the B.S. or the M.S. include: nuclear engineering, mining engineer, chemical engineer, and energy engineer. Those students who have accomplished the advanced degrees, however, would be in a position to demand the higher salaries.

The average graduating student at BYU is often one to two years older than students at other institutions. This is a result of the church related mission travel program. Approximately 75% of the BYU students participate in the LDS mission program.

PROGRAM REQUIREMENTS

Admission to BYU is predicated upon academic achievement as demonstrated by the students secondary educational experiences and results of the American College Test. In addition, students are accepted with the provision that they maintain the ideals and standards inherent in the philosophy of The Church of Jesus Christ of Latter Day Saints (LDS). The prospective graduate student must take the Graduate Record Examination (verbal, aptitude, and advanced engineering).

Students pursuing the Bachelor of Science degree must complete basic courses in chemistry, mathematics, physics and chemical engineering. In addition, the student must complete 11 semester hours in required courses such as statistics and water quality management, and seven to eight semester hours in elective courses such as environmental biology, environmental geology and water and sewage microbiology.

The Master of Science students must complete a minimum of 24 semester hours plus a thesis. Required course work includes at least 12 semester hours in chemical engineering.

Requirements for the completion of the Doctor of Philosophy degree are established by the graduate advisory committee.

There is no internship program or applied study term at present. BYU places strong emphasis on cooperative education programs, however, and thus encourages on-the-job working experience. Pursuant to this philosophy, approximately 30% of the students find employment related to their academic program. This activity usually is undertaken for one semester.

Student financial support may be augmented by means of several long and short-term loans. In addition, there are several scholarship programs for both undergraduate and graduate students.

CURRENT FACULTY, STUDENTS, GRADUATES

The total current faculty includes 12 full-time teaching and research personnel of which six are supported by research contracts.

Currently within the College of Engineering, there are approximately 250-350 chemical engineering students. Of those, 38 are involved in the energy and environment option. The enrollment includes 17 undergraduates and 20 graduate students (of which approximately 8 are doctoral students).

The program staff is not involved in an active follow-up program of graduates. The graduates, however, at all levels have no difficulties in obtaining employment in their field. According to the faculty, the graduates are actively recruited by industry.

PROGRAM PROJECTIONS

During the last five years, the number of students in chemical engineering has doubled, yet there has been no change in the number of faculty. The faculty, therefore, is expected to increase by one person with expertise in an energy area, within the next two to three years.

The number of students has now stabilized and there is a university wide freeze on expanding the present enrollment which totals approximately

25,000 students. The chemical engineering program, therefore, will probably not experience much of an increase in student enrollment over the next two to three years.

The department has made plans to develop a new energy and environment course to be included in the general education offerings. It is felt, by the department, that the energy and environment course would be beneficial to students from other areas of study. No time-lines have been established, as yet, for this addition.

COURSE DESCRIPTION

Undergraduate courses:

ChEn 100 Introduction to Chemical Engineering I - The chemical engineering profession, process synthesis concepts, field trips to selected industries, and problem solving. (1 1/2 s.h.)

ChEn 101 Introduction to Chemical Engineering 2 - Machine computation and use of computers to solve engineering problems. Fortran programming, and numerical methods of problem solving. (1 1/2 s.h.)

ChEn 110 Energy and Society - History and future of traditional energy sources. Development and technology of new energy sources. (1-3 s.h.)

ChEn 273 Chemical Process Principles - Material and energy balances. (3 s.h.)

ChEn 219R Undergraduate Seminar - Department discussions, interchange with faculty, professional activities.

ChEn 373 Chemical Engineering Thermodynamics I - First and second laws of thermodynamics, applied to the behavior of real fluids. Physical and chemical equilibrium. (3 s.h.)

ChEn 374 Unit Operations I - Fluid mechanics, including process flow, hydraulic equipment, solids handling, and size reduction. (3 s.h.)

ChEn 376 Unit Operations 2 - Heat and mass transfer, including conduction, radiation, diffusion; steady and unsteady state; transport analogies; design applications. (3 s.h.)

ChEn 378 Science of Engineering Materials - Principles and properties of materials and their behavior applied to engineering. (3 s.h.)

ChEn 399R Cooperative Education: Chemical Engineering - Students must meet departmental requirements and consult adviser prior to enrollment. On-the-job training experience. Report required. (1-3 s.h.)

ChEn 464 Chemical Engineering Plant Design and Economics - Design of chemical engineering machinery plants and/or processes requiring the application of unit operations: chemical process principles; economic analysis. (2 s.h.)

ChEn 474 Chemical Engineering Thermodynamics 2 - Continuation of Chem. Eng. 373. (2 s.h.)

ChEn 475 Unit Operations Laboratory I - Experimental verification of unit operations design principles, data collection and reduction, and report preparation. (2 s.h.)

ChEn 476 Unit Operations 3 - Stage operations, distillation, extraction, and absorption; design applications. (3 s.h.)

ChEn 477 Unit Operations Laboratory 2 - Experimental verification of unit operations design principles, data collection and reduction, and report preparation. (2 s.h.)

ChEn 478 Chemical Engineering Kinetics - Theories and applications of chemical kinetics in catalytic and noncatalytic reacting systems. (3 s.h.)

ChEn 491R Seminar - Technical presentations by students, faculty, and guests. Required of all majors in the senior year. (1/2 s.h.)

ChEn 493R Special Topics-Undergraduate - Prerequisite: consent of instructor. (1-3 s.h.)

ChEn 498R Special Problems-Undergraduate - Prerequisite: consent of instructor. (1-3 s.h.)

ChEn 499R Undergraduate Thesis Research - (1-3 s.h.)

ChEn 510 Energy and Fossil Fuels - Energy sources and demands; energy processes, costs, and relation to environment; design applications and case studies, emphasizing coal gasification and shale oil recovery. (3 s.h.)

ChEn 520 Air Pollution Control - Causes and effects of air pollution; standards, criteria and legislation; dispersion, meteorology and atmospheric chemistry. Includes design project and use of impact statements.

ChEn 550 Process Synthesis - Synthesis of chemical processes from process components including optimization and economic factors. Case study. (2 s.h.)

ChEn 551 Process Control and Dynamics - Dynamics of process systems and associated control systems and instrumentation. (2 s.h.)

ChEn 582 Introductory Nuclear Engineering - Principles and application of nuclear reactor design. (3 s.h.)

ChEn 583 Nuclear Reactor Engineering - Nuclear reactor design, including heat transfer, energy conversion, reactor materials, instrumentation and control, fuel management, economics, and comparison of principal power system concepts. (3 s.h.)

ChEn 599R Cooperative Education: Chemical Engineering - Students must meet departmental requirements and consult adviser prior to

ChEn 599R (cont'd) - enrollment. On-the-job training experience. Report required. (1-3 s.h.)

Graduate courses:

ChEn 672 Non-Newtonian Fluid Mechanics and Heat Transfer - Laminar and turbulent flow and heat transfer for non-Newtonian fluids, two phaseflows, flow through porous media, mixing and agitation, engineering applications. (2 s.h.)

ChEn 673 Transport Phenomena - General differential equations of conservation of mass, heat, and momentum; transport coefficients; turbulent flow; interphase transfer, etc. (3 s.h.)

ChEn 674 Advanced Thermodynamics and Calorimetry - Advanced thermochemistry applied to measurement of heats of mixing, heat of reaction, equilibrium constant, etc. (2 s.h.)

ChEn 675 Thermodynamics of Multicomponent Systems - Advanced course involving fundamental concepts and applications in first and second laws, equilibrium and stability, phase equilibrium, homogeneous and heterogeneous chemical equilibrium. (3 s.h.)

ChEn 676 Advanced Diffusional Operations - General theory of differential and stagewise diffusional and separations operations; multicomponent distillation extraction, absorption; solution of complex problems; column design and instrumentation. (3 s.h.)

ChEn 677 Creative Skills in Chemical Engineering - Applying creativity and prior course work to the solution of relevant open-end problems. (1 s.h.)

ChEn 681 Kinetics and Catalysis - Applying fundamental theories of chemical kinetics and transport phenomena to the design of chemical reactors. (3 s.h.)

ChEn 683 Advanced Plant Design and Economics - Comprehensive design of chemical plants including feasibility and market surveys, economic evaluations, raw materials, plant layout, process design, instrumentation, materials of construction. (2 s.h.)

ChEn 691R Seminar for Master's Students - Technical presentations by graduate students, faculty members, and guests. (1 s.h.)

ChEn 693R Special Topics-Graduate - (1-3 s.h.)

ChEn 698R Special Problems-Graduate - (2-6 s.h.)

ChEn 699R Thesis for Master's Degree

Chem 769R Selected Topics in Physical Chemistry - (1-3 s.h.)

ChEn 791R Seminar for Doctoral Students - (1 s.h.)

ChEn 793R Selected Topics in Chemical Engineering - Topics vary according to student-faculty research interests. (1-3 s.h.)

ChEn 799R Dissertation for Doctoral Students

INSTITUTION: CARNEGIE-MELLON UNIVERSITY
CARNEGIE INSTITUTE OF TECHNOLOGY

PROGRAM: Environmental Engineering

DEPARTMENT: Civil Engineering

DEGREE: Bachelor of Science (B.S.), Master of Science (M.S.)
Master of Engineering (M.E.), Doctor of Philosophy (Ph.D.)

CONTACT: Dr. Francis Clay McMichael
Head, Department of Civil Engineering
Carnegie-Mellon University
Carnegie Institute of Technology
5000 Forbes Avenue
Pittsburgh, Pennsylvania 15213
(412) 621-2600

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Environmental engineering is not emphasized as a formal program at the Carnegie Institute of Technology. Emphasis is placed on research on environmental topics which is mainly conducted by departments of the College of Engineering. The principal areas of research are air pollution, industrial wastewater, solid waste management and energy. The prinicpal degree granting departments in the College conducting environmental research are the Chemical, Civil, Mechanical and Engineering and Public Policy Departments. The Engineering and Public Policy Department is also part of the Graduate School of Urban and Public Affairs. All of these departments are involved in undergraduate projects and graduate thesis research in the field of environmental engineering.

Selected institutes or research programs of the Carnegie Institute of Technology which are involved in environmental engineering are the Environmental Studies Institute (to be renamed the Center for Energy and Environmental Studies) which grants an M.E. in Environmental Studies, and the Division of Nuclear Science and Engineering.

The Department of Civil Engineering offers a graduate study option in Environmental Engineering. Emphasis is on water and wastewater treatment and management, and students receive a sound understanding of water science and water process technology. The Department cooperates with other departments and colleges within Carnegie-Mellon University to sponsor interdisciplinary programs leading to special degrees or joint degrees.

Research facilities for use of students in the program include an Environmental Engineering Laboratory for research mainly in the areas of water and wastewater chemistry. A unit operation laboratory is also utilized for both teaching and research. A clean laboratory is presently under construction for aerosol studies. Analytical facilities are available to measure common inorganic and organic indices of water quality.

PROGRAM REQUIREMENTS

The Department of Civil Engineering offers a variety of degrees at the Master's level. They include: M.S. in Civil Engineering; M.S. in Civil Engineering/Engineering and Public Policy; and Master of Engineering. The Master of Science degree requires a minimum of 96 academic units consisting of:

(1) at least 36 units of graduate courses in Civil Engineering;
(2) a minimum of 24 (a maximum of 42) units of graduate project,
(3) other approved courses as suggested by the faculty advisor, and;
(4) satisfactory completion of either a comprehensive final examination or an M.S. thesis.

The Department's Master of Engineering degree normally requires a minimum of 192 units of work with strong emphasis on interdisciplinary project work. Students register in an enigneering department but select problems drawn from areas such as the environment. Ph.D. cnadidates complete an additional two years of graduate study beyond the M.S. degree. A qualifying examination and final examination are required, but no foreign language is required. There is a one-year residence requirement for the Ph.D.

Research assistantships, teaching assistantships and fellowships are offered to graduate students as financial aid. A much greater number of assistantships is available in comparison with the number of fellowships. Graduate assistantships are usually one-third time appointments requiring 12 hours of work for the Department weekly.

CURRENT FACULTY, STUDENTS, GRADUATES

The College of Engineering faculty, totaling about 90, teach both undergraduate and graduate students. The faculty devote about 67 percent of their time to teaching and 33 percent to research activities. The Civil Engineering faculty is composed of thirteen members, of whom six are full professors. Three professors have research interests in environmental engineering areas.

During 1977, the College of Engineering had research expenditures totalling about $6 million, of that amount, $3 million was for energy research, and one-third of the energy expenditures ($1 million) was for environmental-energy research. The main funding source is the National Science Foundation, and ten percent is provided by industry.

The College of Engineering has a total undergraduate enrollment of 1,200 students, most of which are full-time. Approximately 90 percent are male. There are about 400 graduate students (5% female) and approximately 40 are part-time. It is estimated that 350 stu dents annually complete the baccalaureate requirements and 100 students earn advanced engineering degrees. In Civil Engineering, twenty students were enrolled in the Master's programs in the fall of 1976, and eight students were enrolled in the Ph.D. program. During the 1975-76 school year, 34 students earned undergraduate degrees, 19 earned Master's degrees and two students received the Ph.D.

Approximately twenty percent of the students receiving B.S. degrees continue directly to graduate schools. It is expected that all graduates obtain employment directly in their field and 70 percent obtain positions in the private sector. Although the university maintains a Placement Office, students are also very successful in obtaining employment through individual contacts.

PROGRAM PROJECTIONS

Emphasis in the environmental engineering program in future years will remain on industry and the attempt to solve environmental and energy, fuel substitution, solar energy, and increased coal use problems. The Civil Engineering Department has no intention of developing a separate undergraduate major in environmental engineering. No change is foreseen in the institutional arrangements for degrees, but an increased emphasis on energy/environmental problems is expected. One additional faculty member was recently added to the environmental engineering program in the Civil Engineering Department. He has a doctorate, and his research interests include air pollution, and specifically, in trace metals in aerosols.

COURSE DESCRIPTIONS

12-721 Dynamic Hydrology - A theoretical basis is provided for analyzing water movement within the hydrology cycle; survey of important principles used in the analysis of ground water flow with applications to basin-wide ground water management; the design of industrial and domestic land and deep well waste disposal systems and to the prevention of water problems in coal mining operations; and other topics. (9 s.h.)

12-722 Wastewater Treatment: Theory and Design - Theory and design of wastewater treatment unit operations including sedimentation, activated sludge, and biological filtration. Material covered includes biological process kinetics, and theory and practice of advanced wastewater treatment processes. The design of solid handling systems focuses on thickening, digestion, incineration, and terminal disposal facilities. Laboratory sessions illustrate chemical principles of dilute aqueous systems and provide familiarity with chemical measurements commonly used in water and wastewater engineering. (9 s.h.)

12-723 Water Resources Chemistry - A rigorous yet practical basis for applying the principles of chemical equilibrium and kinetic models and physical chemistry to a description of the composition of waters and to water and wastewater treatment processes. Laboratory sessions illustrate chemical principles of dilute aqueous systems and provide familiarity with chemicals measurements commonly used in water and wastewater engineering. (9 s.h.)

12-732 Special Topics in Environmental Engineering - Development and application of models for assessing environmental problems with an emphasis on air pollution. Both elementary and more advanced models will be discussed. Consideration will be given to causes and effects of air pollution, control technologies, energy consumption rates and costs, and the need for efficient data collection and management. The course also includes studies of modeling atmospheric transport of air pollutants from source to sink. Offered from time to time as demand warrants. (9 s.h.)

INSTITUTION: COLUMBIA UNIVERSITY

PROGRAM: Nuclear Engineering

DEPARTMENT: Mechanical and Nuclear Engineering

DEGREE: Bachelor of Science (B.S.)
Master of Science (M.S.)
Nuclear Engineer
Eng. Sc. D.

CONTACT: Dr. William W. Havens, Jr.
Director, Division of Nuclear Science and Engineering
School of Engineering and Applied Science
Seeley W. Mudd Building
Columbia University
New York, New York 10027
(212) 280-3284

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Nuclear engineering programs were initiated at Columbia in 1951 and are offered at both the undergraduate and graduate levels. They are designed to give students knowledge of the technology involved in the utilization and application of nuclear fission and fusion. An environmental option is available at the undergraduate level but has attracted little attention in the five years it has been offered. Only two or three students have so far selected it.

Research funding for the program is provided by the federal Department of Energy. Facilities include a nuclear technology laboratory which was partially funded by the former Atomic Energy Commission, and the computer systems of the engineering school. Arrangements have also been made for the use of the Brookhaven and Oak Ridge National Laboratories when needed.

PROGRAM REQUIREMENTS

The admission requirements for the B.S. program include a high school diploma, recommendations from the student's principal and teachers, and the Scholastic Aptitude Test plus three achievement tests. It is also recommended that students have completed four years of high school english literature and composition, four years of math, two or three years of foreign language, three or four years of history and social studies, and two or three years of laboratory science.

Admission to the M.S. program includes a B.S. in nuclear, mechanical, chemical, or electrical engineering or in metallurgy, physics, or engineering mechanics, with an above average record. For admission to the Nuclear Engineer program an M.S. in nuclear engineering or any other engineering branch with a nuclear minor is required. Requirements for admission to the Eng.Sc.D. program include an M.S. degree or equivalent course work in nuclear engineering or physics or in mechanical or chemical engineering or metallurgy with a nuclear minor.

A B.S. degree requires a minimum of sixty-five credit points in the freshman and sophomore years and an additional sixty-five credit points in the junior and senior years, including at least twenty-eight points of nontechnical courses approved by the Dean. Requirements for the M.S. degree include at least thirty credit points beyond the B.S. level, including a minimum of eight points of electives. The Nuclear Engineer degree requires as a minimum, thirty credit points beyond the M.S. degree and a thesis concerned with a design problem. The emphasis in the Nuclear Engineer degree program is on the design and development aspects of nuclear engineering while the emphasis in the Eng.Sc.D. program is in the demonstration of original research ability. Requirements for the Eng.Sc.D. include at least thirty credit points beyond the M.S. degree. Additional requirements include twelve credit points must be obtained in N.E. 9800 - Doctoral Research Instructions, a doctoral qualifying exam, demonstration of a reading knowledge in two foreign languages in which there is significant technical literature, one of which must be Russian, German, or French, and a doctoral dissertation.

CURRENT FACULTY, STUDENTS, GRADUATES

Seven full-time faculty members participate in the program, six of whom divide their time equally between teaching and research and one researcher. The research funding is provided by the U.S. Department of Energy.

There are thirty-five full-time students currently enrolled in the undergraduate program and twenty-six full-time and twelve part-time students in the three graduate programs. About seventy-five percent of these students are from the New York City metropolitan area. No specific recruiting is done for the nuclear engineering program and it is expected that many students become aware of the program through informal contacts and the reputation of the program. Several students are receiving some form of financial assistance. At the undergraduate level, university scholarships are available and at the graduate level there are currently three students receiving teaching assistantships, three receiving research assistantships, and one receiving a fellowship.

Approximately seventy-five percent of the B.S. graduates go on to further training while of the remainder, about seventy-five percent find employment in the private sector and the other twenty-five percent work in government jobs. Of the graduates in the M.S. program, less than one-third continue their education and of all the graduate degree students going directly into employment, it is estimated that thirty percent work in the private sector, sixty percent in government, and the remaining ten percent go into teaching and research. Most students are placed in positions through contacts and referral by faculty members. The University placement service is somewhat helpful to undergraduates.

PROGRAM PROJECTIONS

No change in the program structure or number of faculty is anticipated. It is hoped however that a nuclear waste management course can be offered within the next couple of years.

COURSE DESCRIPTION

Introduction to Nuclear Science - An introduction to those aspects of the physics of the nucleus which are important to nuclear engineering. (3 s.h.)

Introduction to Nuclear Technology - The non-neutron aspects of nuclear technology and their interaction with the purely nuclear features. (3 s.h.)

Introduction to Design Projects in Nuclear Technology - This course examines design problems chosen from among those often encountered in the nuclear industrial field. (3 s.h.)

Nuclear Fuel Management - Overview of reactor types and fuel cycle, reactor core analysis (generation of group constants, fuel cell, assembly and core analysis), core depletion (Boron let-down curve, fuel depletion, fission products buildup, uranium and plutonium isotopes and assembly power-sharing and burnup), reactivity control and reactivity coefficients, hot channel factors, reactor startup tests, core follow, Pu recycle, core loading and fuel reshuffle, fuel cycle economics (safety considerations and waste management), spent fuel transport, fast and thermal breeder. (3 s.h.)

Radiation Shielding - Sources and biological effects of radiation. Primary interactions of radiations with matter. (3 s.h.)

Special Problems in Nuclear Science and Engineering - A series of individual offerings are made over a three or four year cycle. Among typical topics are fast reactors: core physics, fuel technology, safety, breeding, economics; environmental effects; containment, thermal effects, radioactive release, and others. (3 s.h.)

INSTITUTION: CORNELL UNIVERSITY

PROGRAM: College Program in Energy Conversion

DEPARTMENT: Interdisciplinary

DEGREE: Bachelor of Science (B.S.)

CONTACT: Dr. David Clark
Director, Ward Laboratory
Department of Nuclear Science and Engineering
Cornell University
Ithaca, New York 14853
(607) 256-1000

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The college program in energy conversion is an individualized two-year program, offered within the School of Engineering and combining the conventional disciplines of nuclear, thermal, and electrical engineering.

This program originated in approximately 1970 and is designed to provide students with an opportunity to pursue interdisciplinary courses of study when one of the conventional programs does not meet the needs and objectives of the student. Although the curriculums are designed to the individual, in consultation with faculty advisors, the program must comprise an engineering major and a minor which forms a coherent curriculum.

PROGRAM REQUIREMENTS

Since the college program comprises the final two years of the undergraduate curriculum, an applicant must meet all the requirements of the Basic Studies program before being admitted. The student must also submit a statement of objective and a listing of proposed courses.

Requirements for the B.S. degree include: an approved program of fourteen major and minor courses, at least seven of which must be in engineering. These must total a minimum of forty-two credit hours, of which at least twenty-one must be in engineering subjects. Four elective courses in liberal studies, with a minimum total of twelve credit hours, are also required, as well as two free electives which must give a total of six credit hours.

A student's College Program Committee is comprised of the faculty advisors who endorse the curriculums, and any changes from the original program must be approved by the committee.

CURRENT FACULTY, STUDENTS, GRADUATES

Six faculty members from conventional disciplines, spend a portion of their time on this program. In addition to teaching in this program, they teach and conduct research in their principal departments of Nuclear, Electrical, or Thermal Engineering. Any research involving this program would also be conducted in one of the participating departments.

There are currently five students that can be identified at being in the program. Because the program is interdisciplinary and the curriculum is flexible, it is possible that other students in the College of Engineering, particularly freshmen and sophomores, are pursuing programs that fulfill the requirements of this one. No recruitment is done for this program and most students become familiar with it during their first two years at Cornell. Student assistance is available in the form of University Scholarships based on need.

Although this program could be considered as terminal since it results in a degree, almost all graduates go on to further study. Most stay at Cornell and pursue graduate programs in nuclear, electrical, or thermal engineering. No figures are available regarding employment or placement of graduates.

PROGRAM PROJECTIONS

No expansion of the program or increase in faculty is foreseen at this time.

COURSE DESCRIPTION (SELECTED)

IMP 442 Pollution Control in Power and Propulsion - The major sources of general power and motive power are also sources of air pollution, thermal pollution, and noise. An introduction to the major problems associated with each of these types of pollution and to possible methods of control. (3 s.h.)

IMP 655 Energy Conversion - Primarily a survey of methods for the direct conversion of heat into electrical energy, with emphasis on efficiency, maximum power, practical application, and limitations. (3 s.h.)

IMP 656 Power Systems I - A broad survey of methods of large-scale power generation, emphasizing energy source, thermodynamics and fluid mechanical cycle consideration, and component description. (3 s.h.)

IP 201 Nuclear Energy and the Environment - Fundamentals of nuclear radiations and their measurement and interaction with matter, the natural radiation environment, and sources of man-made radioactivity (5 weeks); environmental effects of nuclear electricity generation and nuclear fuel mining, processing and waste storage, control of radiation hazards, and waste heat problems, among other topics. (3 s.h.)

IP 634 Nuclear Engineering Design Seminar - A group design study of a selected nuclear reactor system. Emphasis is on safety, siting, and radiation protection in the design of nuclear power systems. (4 s.h.)

INSTITUTION: CORNELL UNIVERSITY

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Science and Engineering

DEGREE: Master of Engineering (M.Eng.)
Master of Science (M.S.)
Doctor of Philosophy (Ph.D.)

CONTACT: Dr. David Clark
Director, Ward Laboratory
Department of Nuclear Science and Engineering
Cornell University
Ithaca, New York 14853
(607) 256-1000

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The nuclear engineering program at Cornell is designed to give students the basic principles of nuclear reactor systems with major emphasis on reactor safety and radiation protection and control.

Established approximately ten years ago, the program offers three graduate degrees: the M.Eng., M.S., and Ph.D. The M.Eng. program is intended as a terminal, professional degree program, but students may continue on into the Ph.D. program. Both the M.S. and Ph.D. programs are research oriented and students design their own programs. Nuclear engineering is interdisciplinary and admits students from a variety of undergraduate backgrounds.

A major supporting facility of the program is the Ward Nuclear Engineering Laboratory, located on campus. Included among the equipment here are two nuclear reactors. The program also has the use of the university's central computing system.

PROGRAM REQUIREMENTS

Admission to the M.Eng. program requires a baccalaureate degree from an accredited engineering program or its equivalent in an appropriate area of engineering or science. The recommended background includes an undergraduate degree in engineering, applied science, or physics, course work in modern physics, math, including advanced calculus, and thermodynamics.

Requirements for admission to the M.S. and Ph.D. programs generally include a baccalaureate or equivalent degree from a college or university of recognized standing.

The M.Eng. program is two-terms in length and includes thirty hours of graduate credit. Required courses treat reactor safety and radiation protection and control in depth and electives are available in radiation biology and physical biology. The requirements include courses in nuclear reactor theory, nuclear reactor engineering, low-energy nuclear physics, nuclear measurements laboratory, an engineering design project, two technical electives, and a math or physics elective.

There are no detailed course requirements for the M.S. and Ph.D. degrees and each student is permitted to plan his own program in consultation with faculty members of his Special Committee. A student in these programs may choose to major in nuclear engineering or nuclear science. Completion of a thesis is required.

CURRENT FACULTY, STUDENTS, GRADUATES

The program has three full-time and five part-time faculty members who divide their time between teaching and research. Research funding for the program is provided principally by the National Science Foundation and by the Electric Power Research Institute at Stanford University.

There are currently twelve students, all full-time, in the program. Few are career change students and no data are kept on whether students are in-state residents or not. The program does no specific recruiting, and generally has more applicants than it can accept. Student assistance is available in the form of fellowships, loans, and assistantships.

The program averages about seven graduates per year with some slight fluctuation. Virtually all students go directly from the program into employment and the majority work for private industry with reactor manufacuturers and engineering and consulting firms. The remainder find jobs with regulatory agencies and in teaching and research.

PROGRAM PROJECTIONS

There are plans to expand the program over the next three years to include courses on fusion technology and place more emphasis on radiation protection and reactor safety. An increase of approximately three faculty members will likely be required for this expansion.

ADDITIONAL INFORMATION

Program officials conduct a summer program for high school teachers from New York and Pennsylvania in nuclear science. This annual program receives funding support from the Energy Research and Development Administration.

COURSE DESCRIPTION

(the following is a partial listing of courses)

IP201 Nuclear Energy and the Environment - Fundamentals of nuclear radiations and their measurement and interaction with matter, the natural radiation environment, and sources of man-made radioactivity (5 weeks); radiation chemistry, radiation biology, somatic and genetic effects of nuclear radiation, movement of radioactive materials in the biosphere, and other topics. (3 s.h.)

IP609 Low-Energy Nuclear Physics - The nuclear interaction. Properties of ground and excited states of nuclei; models of nuclear structure; resonant and nonresonant scattering, absorption, and fission. (4 s.h.)

IP612 Nuclear Reactor Theory I - A first course in the physical theory of fission reactors. The fission process and the essential properties of neutron interactions with matter are described. (4 s.h.)

IP633 Nuclear Reactor Engineering - A selected set of topics representing the fundamentals of nuclear reactor engineering. (4 s.h.)

IP634 Nuclear Engineering Design Seminar - A group design study of a selected nuclear reactor system. Emphasis is on safety, siting, and radiation protection in the design of nuclear power systems. (4 s.h.)

IP651 Nuclear Measurements Laboratory - Laboratory experiments plus lectures on interaction of radiation with matter and on radiation detection, including electronic circuits. The student is expected to perform eight to ten experiments selected to meet the student's needs. Some stress is placed on independent work by the student. (4 s.h.)

INSTITUTION: GEORGIA INSTITUTE OF TECHNOLOGY

PROGRAM: Energy Engineering
DEPARTMENT: College of Engineering
DEGREE: Certificate of Achievement

CONTACT: Dr. Charles R. Vail, P.E., Associate Dean
College of Engineering
Georgia Institute of Technology
225 North Avenue, N.W.
Atlanta, Georgia 30332
(404) 894-3354

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The College of Engineering offers students the opportunity to pursue a bachelor's, a master's, or a doctorate degree in one of nine of the standard engineering disciplines (i.e., aerospace engineering, ceramic engineering, electrical engineering, industrial and systems engineering, textile engineering, mechanical engineering, nuclear engineering, and architecture), with a multidisciplinary specialization in energy engineering. In addition to these students' earning their respective degrees, they are also awarded a certificate of achievement upon graduation.

The multidisciplinary program in energy engineering emphasizes the fundamental aspects of energy in its various forms and it deals with energy sources, fuels, conversion, transmission, utilization, and storage, as well as with the treatment of effluents and waste heat. It considers also the physical, technological, social, ecological, and economic interrelationships and constraints which enter into energy engineering practice.

Current research opportunities range from the fundamentals of multiphase flow and transport through fixed and variable mirror solar collectors, through the design of hybrid environmental control systems, to fundamental characteristics of high temperatures, high pressure plasmas and their associated electrical phenomena.

Students seeking the energy certificate must fulfill all of the degree requirements of their schools as well as the certificate requirements for the multidisciplinary program. Upon graduation, both the degree and the certificate are awarded. These people will be qualified to work in traditional engineering positions, or they will be prepared to work in the area of energy technology (current and alternate).

PROGRAM REQUIREMENTS

For admission to the undergraduate program, one must have completed four years of high school English, two of algebra, one of plane geometry, one-half of advanced algebra, one-half of trigonometry, one year of chemistry, one of a lab science, and one of history. All undergraduate applicants are also required to submit SAT scores.

Specific undergraduate-level minimum certificate requirements include: Architecture 4775, 4776, and 4777, or the equivalent, totaling nine credit hours; at least four additional credit hours in thermodynamics; at least six additional credit hours selected from a list of courses approved by the energy engineering faculty committee; and an average of B or better in the courses which are to be counted toward satisfying the certificate requirements.

Full graduate-level standing will be accorded applicants holding a bachelor's degree from an approved institution, and whose previous work has been of a nature and quality sufficient to offer reasonable assurance of success in advanced study. Conditional graduate standing will be assigned to those students whose previous work shows deficiencies in either content or quality.

Master's students have the option of writing a thesis or not writing one. Should they elect a non-thesis course of study, they must prepare a special report in its place, and make an oral presentation of it. Students who are pursuing the Ph.D. degree must be in residence for at least three quarters and they must prepare a research project which will culminate in a dissertation.

Specific graduate level minimum certificate requirements include: a minimum of twenty-one credits of course work at or above the 6000 level selected from an approved list and including at least three credits each in thermodynamics, heat transfer, fluid flow, control systems, and energy systems, plus six credits of either more advanced courses in the above areas or approved courses concerned with the economic aspects of energy generation, transmission and/or use; formal instruction in the origination and development of proposals for research and development support, in conducting and reporting on research and development activities and the utilization of their results; either six credit hours of special problem work or seventeen hours of thesis work on an approved energy-related subject; and finally a grade point average of no less than 3.2 (on a 4.0 scale) on the above designated work.

CURRENT FACULTY, STUDENTS, GRADUATES

Energy engineering is administered by one faculty member from each of the nine cooperating departments. In addition, one faculty member each from civil engineering and chemical engineering are on this committee in anticipation of this option soon being a part of the offerings in their respective departments.

Students do not declare pursuit of a certificate until one quarter prior to their graduation; for that reason, it is impossible to know how many students plan to receive this certificate. Since 1975, one bachelor's student in mechanical engineering and two students, one bachelor's and one master's, in architecture have received the Energy Certificate of Achievement.

These graduates will be qualified to find employment in the traditional occupations respective of the school from which they received their degree, and they will also be able to work in specialized energy-related fields.

PROGRAM PROJECTIONS

The multidisciplinary approach to a particular problem area, energy for example, appears to be an important development in environmental education, and is creating something of a "stir" among industrial representatives. These programs are being expanded in this college so that when a person graduates he/she will receive a multidisciplinary degree with major work in three or more cooperating departments. Officials expect to increase student interest in these multidisciplinary environmental programs through an advertising effort. Officials note that there has been a growing number of requests for information about these programs from prospective students.

COURSE DESCRIPTION (SELECTED)

A.E. 4250 Jet Propulsion - Theory and principles of jet propulsion. Mechanics and thermodynamics of combustion. Component and cycle analysis. Engine performance characteristics. (5 q.h.)

A.E. 6260 Thermodynamics of Gases - Thermodynamics of reacting gases. Introductory quantum theory, statistical thermodynamics and chemical kinetics. (4 q.h.)

A.E. 6262 Combustion II - Laminar diffusion flames and droplet burning. Laminar flame propagation in premixed gases, turbulent flames, ignition quenching and flammability limits. Chemical reactions in boundary layers. (3 q.h.)

A.E. 4775 Sociotechnical Problems in Energy Engineering - Examination of problems and opportunities in area of energy from social and technical viewpoints. Analysis presented to develop a multidisciplinary perspective. (3 q.h.)

Arch. 4476 Impact of Energy Problems - Provides a working knowledge of interaction and impact of energy on the individual and society. (3 q.h.)

Arch. 4777 Energy Flow in a Systems Context - Energy and energy flow in a systems context. (3 q.h.)

Cer.E. 4004 High Temperature Thermodynamics - Chemical thermodynamics data used to predict reaction directions and study

Cer.E. 4004 (Cont'd) - vaporization processes. Use of various gas mixtures to control oxygen pressures. (2 q.h.)

E.S.M. 6411 Energy Methods in Mechanics - Virtual work, minimum total potential energy, minimum complementary energy, Castigliano's theorems, applications of calculus of variations, Rayleigh-Ritz method. (3 q.h.)

E.E. 3330 Electromechanical Systems and Energy Conversion - Fundamentals of electromechanical energy conversion, electromechanical energy conversion, electromechanical devices and systems. Energy state functions, force energy relationships, basic transducers, introduction to A.C. and D.C. machines. (3 q.h.)

E.E. 6500 Introduction to Management and Control of Energy Systems - Fundamentals of static and dynamic system theory as applied to typical energy engineering problems. Optimization theory, decision analysis techniques for large-scale systems. (3 q.h.)

E.E. 6501 Planning of Power Systems - Introduction to planning procedures for large scale technical operations. Technical and economic constraints on planning. Techniques for formulation of rational planning problems. (3 q.h.)

E.E. 6502 Control and Operation of Interconnected Power Systems - Operation of interconnected systems. Models for system interaction, techniques for control and management of power flow and reliability. (3 q.h.)

E.E. 6503 Evaluation of Power System Reliability - Techniques for the study of power system reliability. Probabilistic models for power system performance. Techniques for subsystem and composite system reliability analysis. (3 q.h.)

E.E. 6504 Computer Applications in Power Systems - Hardware and software computer requirements for load flow, stability and short circuit computations in power systems. Real-time applications to power systems such as monitoring, estimating, protective relaying and hierarchical computer control. Uses and limitations of microprocessors in power applications. (3 q.h.)

M.E. 6324 Thermodynamics III - Statistical thermodynamic calculation of properties of ideal gases, real gases, solids and gas mixtures. Kinetic theory and transport properties. Thermodynamics of special systems. (3 q.h.)

M.E. 6352 Energy Conversion Systems - Alternative energy conversion systems and analysis of economic and commercial performance characteristics. Comparative analysis of Otto, Diesel, Brayton, Rankine, solar and direct energy conversion systems. (3 q.h.)

M.E. 6357 Combustion III - Combustion in turbulent boundary layers. Spontaneous ignition and explosions. Flame propagation and

M.E. 6357 (Cont'd) - flammability limits. (3 q.h.)

M.E. 6360 Solar Energy Engineering - Fundamentals of solar radiation, transmission and absorption. Flat plate and focusing collectors. Thermal storage. Heating and cooling of structures. Distillation. Process heat supply. Power generation. (3 q.h.)

M.E. 6370 Thermal Environmental Control - Thermodynamic relations of moist air. Air conditioning processes. Environmental systems for thermal comfort. Direct and indirect contact transport processes. (3 q.h.)

N.E. 6621 Thermonuclear Engineering II - Engineering problems related to development of controlled thermonuclear fusion. Energy removal systems, radiation damage, tritium breeding, magnetic field generation, direct conversion, environmental effects. (3 q.h.)

N.E. 6680 Advanced Energy Conversion I - Energy sources, dynamic systems, thermoelectric conversion, fuel cells, solar power, MHD and design of practical and useful power systems. (3 q.h.)

N.E. 6681 Advanced Energy Conversion II - Explores topics covered in N.E. 6680 in greater depth. Current programs aimed at developing advanced power sources. (3 q.h.)

INSTITUTION: HARTFORD STATE TECHNICAL COLLEGE

PROGRAM: Nuclear Engineering Technology

DEPARTMENT: Nuclear Technology

DEGREE: Associate in Science

CONTACT: Dale Robinson, P.E.
Nuclear Technology Department
Hartford State Technical College
401 Flatbush Avenue
Hartford, Connecticut 06106

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Hartford State Technical College's two year Nuclear Engineering Technology Program is the only technology program of its kind on the East Coast and possibly the entire United States. A broad understanding of the engineering applications of radioisotopes and ionizing radiation is the general goal of education to be provided to students. Studies include radiation safety, atomic and nuclear physics, health physics, and various applications of current instrumentation techniques. Students find jobs as industrail radiologists, instrumentation technicians, radio-chemistry technicians, health physics technicians, reactor operators, and research assistants.

Hartford State Technical College is accredited by the New England Association of Schools and Colleges, Inc. and the Connecticut Commission for Higher Education. The Engineers' Council for Professional Development is the accrediting body for the Nuclear Technology Program. The College has a reputation in the New England areas as providing instruction in the civil, mechanical, and electrical technologies.

Available to students in the Nuclear Engineering Technology Program is an extensive laboratory which includes chemical equipment, scalers, rate meters, single and multi-channel analyzers, x-ray machines, and other equipment. The laboratory is recognized as providing more than enough instrumentation facilities to handle student needs.

PROGRAM REQUIREMENTS

In order to enter this program, prospective students must be vocational technical or high school graduates or possess a State Equivalency diploma. Students with no mathematics or science background must pass a pre-technical program. Students must also take the mathematics/science portions of the Engineering and Physical Science Aptitude test which is an admissions examination .

The Nuclear Engineering Technology curriculum requires two years of study broken into six quarterly periods. Each quarter contains a specified number of class and laboratory hours of credit. Included in the total of 119 quarter hours of credit are 102 class and 40 laboratory hours. Students may also take two additional electives during their last two quarters and these usually include further calculus if a student desires to continue on to an engineering bachelor's program for their third year.

Most of the students have part-time employment to supplement their educational costs and many receive Basic Educational Opportunity Grants. The College has relatively low tuition so financial aid is not normally a critical problem. Several hundred dollars is also available through the federal and state Work-Study Program.

CURRENT FACULTY, STUDENTS, GRADUATES

Only one faculty member has a full-time teaching position within this program. The Nuclear Technology Department offers twelve courses for its students and supplements these with courses offered by other departments.

There are currently (Fall, 1977) twelve students enrolled in the program. Approximately nine to ten students graduate annually from the program,on the average. The trend in enrollment has been declining and nine students including two females graduated from the program in June, 1977. A small percentage of students enter the program on a career change basis and those that do often come with an electronics technology background.

Program officials estimate that approximately sixty percent of the graduates continue onto a Bachelor degree program and those doing so are more likely to work in the field as a nuclear technologist. Many continue to nuclear engineering programs offered by the University of Lowell, the University of Hartford, and the Rensselaer Polytechnic Institute. About sixty-five percent of the program's graduates have found employment in the field while thirty percent have found jobs in a related field. Many of those finding jobs in a related field have found positions as nuclear engineers with firms such as United Aircraft in which they utilize instruction offered by the program but which are not specifically nuclear engineering. Only about five percent of the graduates have found jobs in an unrelated field. It is estimated that the graduates have been most successful in finding positions in the private sector.

The College maintains a placement service to assist students and alumni in obtaining jobs. Employers have visited the college interviewing prospective employees from organizations, as the Tennessee Valley Authority and the U.S. Navy at Newport News. At times employers have called the Department requesting interviews with students but the students have had much more success arranging their own contacts.

PROGRAM PROJECTIONS

Due to a trend of decreasing enrollment, the Nuclear Engineering Technology may eventually suspend its A.A.S. degree program. In the past, several courses have been combined and environmental protection courses have also been offered to enable students to become more employable. The program may eventually develop an energy related curriculum to replace the Nuclear Engineering Technology program. However, so far the program has been able to maintain its present emphasis and no change may actually occur within the next five year period. Also, it is not expected that any additional faculty members will be recruited due to the declining enrollment trend.

COURSE DESCRIPTION

NT 112 Nuclear Materials - This course consists of an introduction to the vocabulary and the processes involved in the preparation of engineering materials for use in the nuclear industry. (2 q.h.)

NT 215 Fluid Mechanics - This course includes a review of the basic properties of fluids and the topics of pressure forces, center of pressure, and interpretation of reading from various kinds of pressure measuring devices. (4 q.h.)

NT 230 Nuclear Physics - A study of the nuclear aspects of modern physics is covered with emphasis on nuclear forces, binding energies, nuclear structure, the phenomena of fission, radiation, and the statistics of counting. (5 q.h.)

NT 240 Radiation Health and Safety - A study of the effects of nuclear radiation on man and his environment is the subject of this course, plus measures necessary for the protection of humans from these effects. (4 q.h.)

NT 250 Nuclear Instruments and Applications 1 - This course is a study of the basic properties of various detection devices used to measure the interaction of radiation with matter. (5 q.h.)

NT 251 Nuclear Instruments and Applications II - This course includes the use of digital computers in nuclear calculations. (5 q.h.)

NT 270 Nuclear Reactors - This is a survey course intended to give the student an over-all picture of nuclear power plant systems, materials, fueling, and other relevant materials. (4 q.h.)

NT 340 Radiation Hazards and Instrumentation - This course covers elementary atomic theory, ionization, x-rays, control of hazards, nuclear fission and fusion, radiation detection equipment, and others. (3 q.h.)

INSTITUTION: KANSAS STATE UNIVERSITY

PROGRAM: Chemical Engineering

DEPARTMENT: Chemical Engineering

DEGREE: Bachelor of Science in Chemical Engineering (B.S.)
Master of Science in Chemical Engineering (M.S.)
Doctorate in Chemical Engineering (Ph.D.)

CONTACT: Dr. L. T. Fan, Head
Department of Chemical Engineering
Kansas State University
Durland Hall
Manhattan, Kansas 66506

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The Department of Chemical Engineering at Kansas State University awards three major degrees--B.S., M.S., and Ph.D. The curriculum offers a broad, fundamental background in chemical engineering science and application to undergraduates, who can also emphasize areas such as chemistry, mathematics, material science, management, computer science, and bioengineering. Graduate students pursue research interests utilizing well-equipped laboratories in transport phenomena, reaction engineering, thermodynamics, biochemical and biomedical engineering, process dynamics and control, and food engineering. The department has shop facilities in which unusual equipment is built and repaired, and the College of Engineering and university computer centers are used extensively.

Research support has come from the National Science Foundation, U.S. Department of Agriculture, U.S. Air Force, Energy Research and Development Administration (now Department of Energy), Environmental Protection Agency, National Institute of Health, and the university's Engineering Experiment Station as well as private sources. The faculty publish actively, and the department is currently engaged in cooperative research projects with Yamanashi University (Japan) and the U.S.S.R.

PROGRAM REQUIREMENTS

Undergraduates must complete 134 semester hours for graduation with a B.S. in Chemical Engineering. Admission to the KSU Graduate School in full-standing requires that the applicant have 1) a bachelor's degree from an approved institution, 2) adequate undergraduate preparation in the propossed major field or equivalent evidence of an advanced background for undertaking an advanced degree program, and 3) an undergraduate average of B or better in the junior and senior years.

CURRENT FACULTY, STUDENTS, GRADUATES

Of the eleven staff members in the department, ten occupy teaching positions though all devote some time to research (30-40 percent); one person is a full-time researcher. Faculty salaries are supplemented by outside sources during the summer months (grants, appointments in other departments). Of the ten Ph.D. and twelve M.S. students, approximately 90 percent are male. Numbers of graduates annually remain stable (two Ph.D., four M.S.); and although KSU's enrollment is increasing rapidly, the Chemical Engineering Department does not seek to expand drastically and beyond its capacity.

Graduates are traced annually through a departmental newsletter, and computerized lists (by employer and location) are maintained. During their careers, chemical engineers can expect to participate in many decisions crucial to the preservation and improvement of society, especially in the areas of energy and food production, resource management, and the specification and design of pollution control processes. Employment opportunities exist in the chemical, petroleum, pharmaceutical, plastics, paper, and food processing industries, as well as government service. Virtually all students completing degrees in this program are employed as chemical engineers (60 percent in the private sector, 10 percent in government, 20% in teaching).

Following a "no assist, no admit" policy at the graduate level, all M.S. and Ph.D. students are supported by state monies or grants ($400-500/month).

PROGRAM PROJECTIONS

Due to student enrollment growth in the past several years, the Department of Chemical Engineering expects to add one or two general curriculum faculty members in the next two years. No major curriculum developments are projected, in part because the existing course structure is flexible enough to adapt to new techniques in chemistry when they are developed. Students are given basic principles and technological skills which are generally useful even as the profession changes.

COURSE DESCRIPTION

Undergraduate and Graduate courses in minor field:

520 531 Transport Phenomena I - A unified treatment of the basic principles of momentum, energy and mass transport. (3 s.h.)

520 531 Transport Phenomena II - Continuation of Transport Phenomena I with special emphasis on mass transfer. (3 s.h.)

520 550 Chemical Reaction Engineering - Applied chemical kinetics and catalysis including the analysis and design of tubular, packed bed, stirred tank and fluidized bed chemical reactors. (3 s.h.)

520 561 Chemical Process Dynamics & Control - A study of the unsteady state behavior of chemical processes, modeling and simulation of chemical processes, classical control theory and design. (3 s.h.)

520 570 Ch.E. Systems Design I - Basic Concepts of optimization and process economics with application to the design of chemical processes. (3 s.h.)

520 571 Ch.E. Systems Design II - The synthesis and design of chemical processing systems. Emphasis will be placed on the solution of comprehensive systems design problems. (3 s.h.)

Undergraduate and graduate courses:

520 715 Biochemical Engineering - The analysis and design of biochemical processing systems with emphasis on fermentation kinetics, continuous fermentations, aeration, agitation, scale up, sterilization, and control. (3 s.h.)

520 725 Biotransport Phenomena - Principles of transport phenomena applied to biological and physiological processes. Membrane transport processes, circulatory system transport phenomena, transport and distribution of drugs. (3 s.h.)

520 805 Selected Topics in Biochemical Engineering - Subjects of current interest in the broadest sense of biochemical engineering. These involve not only chemical engineering problems which contain biochemical, biological or medical elements but also application of chemical engineering principles and methodologies to biochemical, biological, medical and ecological problems. (3 s.h.)

Graduate courses:

520 822 Advanced Chemical Reaction Engineering - Theory of kinetics and catalysis in homogeneous and heterogeneous systems, with application in chemical reactor design and process development. (3 s.h.)

520 826 Advanced study of mass transfer operations. (3 s.h.)

520 850 Advanced Chemical Process Dynamics - The dynamical behavior of chemical reaction systems and process equipment used in chemical plants. Control mechanisms for these systems. (3 s.h.)

520 862 Advanced Transport Phenomena I - Advanced treatment of momentum, energy and mass transport, with emphasis on momentum transport in chemical engineering applications. (3 s.h.)

520 867 Advanced Transport Phenomena II - Advanced treatment of momentum, energy and mass transport, with emphasis on energy and mass transport in chemical engineering applications. (3 s.h.)

520 871 Advanced Process Design and Optimization - Advanced problems in the optimal design and economic evaluation of plant equipment and processes for the chemical and allied industries. (3 s.h.)

520 910 Selected Topics in Transport Phenomena - Subjects of current interest such as surface phenomena, turbulent transport, droplet mechanics, multi-component systems. (3 s.h.)

520 915 Selected Topics in Process Dynamics - Study of the most recent methods for analysis of the dynamic behavior and control of complex systems and industrial processes. The use of Lyupanov theorems and the maximum principle are examples of the methods to be studied. (3 s.h.)

520 920 Selected Topics in Unit Operations - Study of topics as zone melting, foam fractionation, membrane permeation, thermal diffusion, and unsteady state operations. (3 s.h.)

520 925 Selected Topics in Process Design and Optimization - Study of advanced methods of process design and optimization, such as modern variational methods and dynamic programming. Applications to be chosen mainly from the chemical and allied industries to include stochastic as well as deterministic problems. (3 s.h.)

INSTITUTION: KANSAS STATE UNIVERSITY

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Engineering

DEGREE: B.S. in Nuclear Engineering
M.S. in Nuclear Engineering
Ph.D. in Nuclear Engineering

CONTACT: Dr. N. Dean Eckhoff
Dr. Richard E. Faw
Department of Nuclear Engineering
Kansas State University
Manhattan, Kansas 66506
(913) 532-5624

PROGRAM DESCRIPTION:

PROGRAM STURCTURE

The curriculum in Nuclear Engineering at Kansas State University is both diverse and flexible for undergraduates and graduate students alike. The B.S. degree--the first such Engineers' Council for Professional Development (ECPD) accredited program--is designed to prepare students for professional positions in industry, government, and private practice. Through technical electives, the student may organize a program suited to his/her particular needs and interests. Undergraduate students take engineering science courses in materials, thermodynamics, particle and continuum dynamics, electronics. circuit theory, and economics. These courses prepare them for more sophisticated courses in nuclear reactor design principles; neutron and charged particle interactions; radiation detection, protection, and effects on materials; nuclear fuel management; industrial isotope applications; nuclear power cycle thermodynamics and siting; and regulation and environmental impact assessment of nuclear power plants. Graduate students pursue individualized plans of study that balance subject matter from other fields with specific research interests and needs of each student.

Facilities available to KSU students and faculty are extensive. The University operates the following laboratories: 250-kilowatt TRIGA Mark II reactor, Radiation Shielding Facility on a 180-acre remote site whith full scale house and other experimental shielding text structures, Neutron Activation Analysis Laboratory, Radioisotope Application Laboratory, Shock-Tube Laboratory, Environmental Monitoring Laboratory, and Radiation Effects and Fuel Processing Laboratory.

In addition to the university cooperative work program for undergraduates, the Department of Nuclear Engineering conducts workshops for high school teachers and sponsors tours with associated lectures through its facilities. Limited reactor operating time can be provided to college and university groups for the performance of reactor experiments. All noncommercial service irradiations can usually be accommodated; and complete or partial, quantitative or qualitative neutron activation analysis can be performed either by outside users or by Department of Nuclear Engineering personnel.

The Department of Nuclear Engineering is currently heading a project to develop educational materials on the nuclear fuel cycle. Research funding for the past three years totals $943,074; sponsoring agencies include the Energy Research and Development Administration, National Science Foundation, State of Kansas, Kansas Gas and Electric, Northwest College and University Association for Science (NORCUS), Oak Ridge Associated Universities, Nuclear Regulatory Commission, Ozark Regional Commission, Radiation Research Associates, Northern Natural Gas, and American Chemical Society.

PROGRAM REQUIREMENTS

The B.S. degree in Nuclear Engineering requires 131 semester hours to complete. For admission to graduate work, a student must have a bachelor's degree from an approved institution and adequate preparation in mathematics and the physical sciences. Candidates for the master's degree can pursue one of two plan-of-study options: (1) a minimum of thirty semester hours of graduate credit including a master's thesis of six to eight semester hours, or (2) a minimum of thirty semester hours of graduate credit in course work only but including evidence of scholarly effort such as term papers, production of creative work, and so forth. The choice of option is based on the recommendation of the student's supervisory committee, and most students follow the first plan. The Ph.D. degree requires completion of sixty hours of coursework, thirty hours of research, and the dissertation.

CURRENT FACULTY, STUDENTS, GRADUATES

The faculty time loads in the Department of Nuclear Engineering are divided 7.1 for teaching and 1.1 for research; there are eight full-time and two part-time staff members. Enrollment figures indicate 100 undergraduate majors, 15 master's students, and 10 doctoral candidates. Numbers of graduates annually vary by degree and are relatively stable. Over the past three years (75/76/77), 17/10/23 B.S., 5/5/5 M.S., and 4/3/0 Ph.D. diplomas have been awarded. Graduates typically enter the engineering field in the areas of design, research, management, and consulting or they choose related work in law or medicine; an overwhelming 90 percent opt for employment in the private sector.

In addition to the undergraduate cooperative work experience available to students, sources of financial support include state-funded graduate research contracts, fellowships (International Atomic Energy Agency and others when available), traineeships (when available), and employment on contracted work in the department.

PROGRAM PROJECTIONS

In existence since 1959, the program in Nuclear Engineering at Kansas State University should not change radically in the near future. Faculty contend that the current curriculum meets foreseeable training needs for the next decade, although there is a need for more traineeships. No staff members, aside from one or two temporary faculty, are to be added in the next five years. Any revisions in the program will be toward providing students with a more comprehensive view of energy.

COURSE DESCRIPTION

Undergraduate credit:

580 110 Nuclear Engineering Concepts - This first course in the Nuclear Engineering curriculum acquaints freshman students with the professional activities and responsibilities of nuclear engineers. It presents this information through lectures, recitations, and laboratory demonstrations. (2 s.h.)

580 116 Nuclear Engineering Seminar - Introduction to professional nuclear engineering. Student career planning. (1 s.h.)

580 315 Introduction to Nuclear Engineering Analysis - Introduction to analytical, statistical, and numerical analysis as applied to nuclear engineering, including computer programming. (3 s.h.)

580 325 Elements of Nuclear Engineering - Nuclear reactions, nuclear energy releases, ionizing radiation, radiation attenuation; introduction to nuclear reactor concepts of criticality, multiplication factor, period, reactivity, neutron lifetime, fission product poisoning; introduction to reactor instrumentation and control, standards for protection against radiation, health physics, nuclear safety, licensing, survey and monitoring instrumentation, instrument calibration, calculation of dose, dose rates, determination of maximum permissible concentrations and body burdens. (3 s.h.)

580 410 Introduction to Nuclear Engineering - A course to acquaint non-nuclear engineers with introductory aspects of nuclear engineering; a study of nuclear reactions, reactor core calculations, reactor safety and dynamics, shielding, fuels, waste disposal, electric power generation and radioisotope applications engineering. (3 s.h.)

580 490 Neutron and Particle Interactions I - Engineering approach to the classical mechanics of the interaction of neutrons and other radiation with matter, production and detection of neutrons and other types of nuclear radiation. (2 s.h.)

Undergraduate and graduate credit in minor field:

580 500 Applied Nuclear Engineering Analysis - Methods and applications of analytical, statistical, and numerical analysis as applied to nuclear engineering including computer programming. (3 s.h.)

580 510 Neutron Activation Analysis - Basic nuclear properties, neutron flux characteristics, nonreactor neutron sources, radiochemical separations, radiation detectors and counting statistics, gamma-ray spectroscopy, analysis of gamma-ray spectroscopic data, case studies. (3 s.h.)

580 511 Radioisotope Applications Engineering - A laboratory course designed to familiarize the student with experimental parameters of importance in the design of engineering systems which make use of radioisotopes. (2 s.h.)

580 515 Nuclear Engineering Materials - An investigation of the properties and behavior of structural materials, fuels, and components in nuclear radiation environments. (2 s.h.)

580 555 Nuclear Reactor Fundamentals - Introduction to reactor cooling. Analysis of power cycles. Basic reactor thermal design. (3 s.h.)

Undergraduate and graduate credit:

580 613 Nuclear Fuel Cycle - A course to familiarize the student with uranium conversion procedures, enrichment techniques, nuclear fuel burnup, spent fuel transport, reprocessing of spent fuel, fission product disposal methods, and economics of the nuclear fuel cycle. (3 s.h.)

580 615 Nuclear Materials Control and Safeguards - The management, control, measurement, accounting, and protection of nuclear fuel and strategic materials in the nuclear fuel cycle. (3 s.h.)

580 630 Applied Reactor Theory - Theory of diffusion and slowing down of neutrons with application to critical and sub-critical nuclear reactors. Measurement of various reactor physics parameters. (4 s.h.)

580 640 Reactor Operations Planning - Licensing, nuclear safety, and reactor operations. Measurement of nuclear reactor parameters. (2 s.h.)

580 650 Environmental Radiation - Radionuclides and ionizing radiation in the environment of natural and artificail origin. Biological effects of radiation. Detection and measurement of environmental radiation. Licensing and regualtion pertaining to environmental radiation. (3 s.h.)

580 655 Radiation Protection Engineering - Principles of radiation protection. Radiation shielding, radiation dosimetry, and administrative aspects of radiation protection. Special applications in nuclear plant design, fuel transportation, and fuel reprocessing. (3 s.h.)

580 675 Neutron and Particle Interactions II - Engineering approach to the quantum mechanics of the interaction of neutrons and other nuclear radiations with mater; theoretical methods for the evaluation of nuclear reaction cross sections required for engineering applications. (2 s.h.)

580 692 Nuclear Reactor Technology - Thermal and neutronic design analysis of nuclear reactors. Nuclear quality assurance. Safety analysis reports. (3 s.h.)

580 695 Nuclear Reactor Laboratory - Experimental investigation of thermal and hydraulic characteristics of nuclear reactors. (1 s.h.)

580 699 Constructive Uses of Nuclear Explosives - Characteristics and effects of nuclear explosives; Plowshare tests; industrial uses of nuclear explosives; scientific applications of nuclear explosions. (3 s.h.)

580 708 Nuclear Fuel Processing Laboratory - Experimental investigation of the methods and principles of separation and purification as they apply to the production and recovery of nuclear fuel and materials. (1 s.h.)

580 715 Radiation Shielding - Introduction to important sources of radiation, kernel concepts, and application of diffusion and ray theory to shielding calculations, applications principally in the field of stationary nuclear reactor shielding. (3 s.h.)

580 720 Nuclear Systems Analysis - Introduction to nuclear reactor kinetics and simulation. Linear stability of reactor systems. Noise analysis. Application of hybrid computers to nuclear systems analysis. (3 s.h.)

580 750 Direct Energy Conversion - Principles and analysis of direct conversion phenomena, with special emphasis on direct conversion of nuclear energy including thermoelectric, thermionic, photovoltaic, magnetohydrodynamic and electrochemical processes. (3 s.h.)

580 761 Radiation Detection and Measurement - Theory of detection of nuclear radiation. Measurement devices and systems. Applications to radiation dosimetry and spectroscopy, and instrumentation systems for nuclear reactors.

580 762 Nuclear Instrumentation - Design and analysis of nuclear instrumentation. Application to nuclear reactor control, radiation dosimetry and nuclear spectroscopy. (4 s.h.)

580 772 Radiation Effects on Materials I - General theory of radiation damage to solids. Specific effects of radiation on nuclear reactor components and materials of construction. Applications to nuclear reactor design. (3 s.h.)

580 774 Radiation Effects on Materials II - General theory of radiation effects on liquids and gases. Principles of radiation chemistry, photochemistry, and biophysics. Medical, agricultural and industrial applications. (3 s.h.)

580 791 Controlled Thermonuclear Reactions I - Principles of controlled thermonuclear processes; fuel cycles; energy-balance considerations; magnetic and inertial confinement; plasma instabilities; plasma heating; neutronics; radiation damage and materials problems; design of experimental power reactors and power-reactor systems. (3 s.h.)

580 795 Separation of Nuclear Fuels - A graduate level course investigating the chemical properties, the methods of separation, purification and reprocessing of uranium, thorium and plutonium. (4 s.h.)

Graduate credit:

580 806 Neutronics I - Particle transport, theories of diffusion, numerical analysis of diffusion, transient core analysis. (3 s.h.)

580 808 Neutronics II - Perturbation theory, core neutronic design, spatially dependent kinetics, reactor control. (3 s.h.)

580 847 Nuclear Power Engineering I - Principles of hydraulic and thermal analysis for nuclear power reactors. Advanced core design. (3 s.h.)

580 851 Nuclear Engineering Laboratory - Reactor kinetics, reactor noise analysis determinations of B/I, reactor power calibration, auto and cross-correlation techniques, pulsed neutron measurement, radiation shielding, radiation effects, activation analysis, neutron diffraction, and heat transfer. (2 s.h.)

580 860 Advanced Topics in Nuclear Engineering - A presentation of various special topics covering advanced nuclear engineering specialities. (var. s.h.)

580 890 Nuclear Engineering Colloquium - Presentation and discussion of progress reports on research, special problems, and outstanding publications in nuclear engineering and related fields. (1 s.h.)

580 925 Transport Theory I - Principles of transport theory, approximation theory, numerical transport algorithms, gamma ray transport. (3 s.h.)

580 926 Transport Theory II - Advanced approximation theories, transport code development. (3 s.h.)

580 947 Nuclear Power Engineering II - Nuclear system analysis and design with computational considerations. System safety analysis. (3 s.h.)

580 970 The Interaction of Radiation with Matter - Classical and quantum theories of the interaction of radiation with matter. Energy and charge transfer processes. Applications to nuclear reactor theory, radiation shielding, and nuclear instrumentation. (3 s.h.)

580 991 Controlled Thermonuclear Reactions II - Continuation of N.E. 791. Collisionless plasmas; theory of plasma waves and instabilities; plasma diagnostics, experimental approaches. Other topics of current interest. (3 s.h.)

INSTITUTION: LAMAR UNIVERSITY

PROGRAM: Energy Resources Management

DEPARTMENT: Geology

DEGREE: Bachelor of Science (B.S.) in Geology

CONTACT:
Dr. William R. Pampe
Professor of Geology
Lamar University
Beaumont, Texas 77710
(713) 838-7713

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Due to the increasing need for energy throughout the nation, educational institutions such as Lamar are responding to this challenge by developing programs related to the search for new energy, and the management of energy resources. Initiated in 1975, this program is considered to be representative of the few currently ongoing nationally. Energy Resource students develop a background in geology, economics and engineering. They may specialize in one of these three areas through the use of elective courses. Graduates are qualified to enter fields such as mining engineer, energy engineer, petroleum geologist, mining geologist or geophysicist. However, it is not uncommon for some of these graduates to work in land management or at banking institutions with interests in energy exploration.

The program itself is offered through the Department of Geology. However, the departments of Business Administration, Economics and Accounting are actively involved in the program.

PROGRAM REQUIREMENTS

Any student meeting the entrance requirements of Lamar is welcome to major in the Energy Resources Management program. The minimum number of credits required for graduation from the program is 127. General course requirements include 61 credits of chemistry, calculus, English composition, technical writing, government, history and physical education. In addition, 61 credits of professional courses are required in accounting, business administration, economics, engineering and geology for graduation. In the fourth year a student may take 12 hours of electives.

There is no internship program or applied study term. Student financial support includes work study, scholarships, grants (i.e., BEOG) and loans based on need.

CURRENT FACULTY, STUDENTS, GRADUATES

Within the Department of Geology, four full-time faculty members are involved with the program. Contributing faculty from other disciplines increase the number of faculty involved in the program to over fifteen.

There are currently 30 full-time students enrolled in the program. Because the program is relatively new, the number of graduates has fluctuated from 5-8 per year. The number of annual graduates will probably increase slightly over the next few years. The program attracts career change students from engineering, oceanography technology and business. There is no active recruitment of students other than by personal contact or through bulletins about the program within the University.

Graduates have no problem in securing jobs in their field. All graduates seem to have found jobs in their field of interest, (95% to private industry and, 5% to the government sector). Graduates are placed through personal contact with industry or requests for graduates which companies make be contacting the department. One of the unique features of this program is the multiple job opportunities available to graduates.

PROGRAM PROJECTIONS

At the present the program emphasis is more vocational than academic or technical. There is no growth projected over the next few years; however, the program will be constantly upgraded. If the program remains successful, as well as the demand, a masters program may be initiated in the next five to nine years.

COURSE DESCRIPTIONS

Acc 231 Principles of Accounting - Concepts and procedures of financial accounting. First, the information gathering, analysis, recording and reporting functions inherent in the complete accounting cycle. Second, the balance sheet areas of asset measurement, liability accounting, and corporate owner's equity accounting. (3 s.h.)

Acc 232 Principles of Accounting - A continuation of Acc 231 with additional financial accounting and concepts, a procedures and uses of managerial accounting. First, a review and elaboration of accounting principles and specialized accounting topics. Second, cost and managerial accounting with basic cost systems, budgeting and special analyses for management. (3 s.h.)

BA 220 Elementary Fortran Applications to Business - To familiarize business students with elementary applications of Fortran as needed in special business situations. (2 s.h.)

BA 331 Business Law - Principles of law which form the legal framework for business activity. Applicable statutes; contracts; agency. (3 s.h.)

BA 335 Principles of Management - A general theory of management presented within the framework of the traditional managerial functions. Stress is placed upon the universality and practicality of business. A basic course for the study of more advanced and specialized aspects of business administration. (3 s.h.)

BA 3301 Business Statistics - Introduction to the quantitative methods of analysis as applied to business problems. Collection of data; charts and tables; analysis; presentation; frequency distribution; averages; dispersion; index numbers; secular trend; seasonal variation; and cyclical fluctuation. (3 s.h.)

BA 3302 Business Statistics - Continuation of BA 3301 including the theory and practical application of normal curve, probable error, and sampling. Correlation and regression; probability theory and models; statistical inference, tests of hypotheses; sample survey methods; and statistical quality control. (3 s.h.)

Eco 231 Principles - Introduction to economic principles. Emphasizes monetary theory; national income analysis; fluctuation and growth; public finance; international trade; and current economic problems. (3 s.h.)

Eco 232 Principles - Allocation of resources; determination of output and prices; distribution; and managerial economics. (3 s.h.)

Eco 335 International Trade - Theories, practices, and problems involved in international commerce between nations. Bases of trade; tariffs; exchange control; international monetary policies; current problems. (3 s.h.)

Eco 4314 Administrative Policy - Fundamental considerations and procedures followed in business policy formulation and administration. Managerial structure; company objectives; coordination of departmental policies; organization of personnel; reappraisals. (3 s.h.)

Eco 434 Economic Development - Introduction to the theories and history of economic growth and development applicable to advanced and emerging economies; analysis of processes of growth including cultural, technological, and economic factors; identification of problem areas with policy implications. (3 s.h.)

Egr 438 Introductory Petroleum Engineering - The modern techniques of producing oil will be reviewed. Drilling operations, primary and secondary recovery operations, methods of evaluation, production rate potential and reserve, as well as other aspects of reservoir engineering will be studied. Prerequisites: Senior/graduate standing. (3 s.h.)

Geo 141 Physical Geology - Earth materials, structures, land forms, mineral resources, and the processes which formed them. (4 s.h.)

Geo 142 Historical Geology - History of the earth and its life. Prerequisite: Geo 141. (4 s.h.)

GEO 344 General Oceanography - Introduction to principles of oceanography. Geology of ocean basins, near shore processes, chemistry of sea water, physics of the sea, and biological environments of the ocean. (4 s.h.)

Geo 419 Seminar - Reports on current literature. (1 s.h.)

Geo 433 Geophysics - Application of the principles of physics to geologic problems. Use of geophysical techniques in petroleum exploration. (3 s.h.)

Geo 437 Economic Geology - Origin and occurence of commercially valuable metallic and non-mettalic minerals and rocks. Exploration for and development of deposits. Field trip required. (3 s.h.)

Geo 438 Petroleum Geology - Origin and occurrence of oil and gas deposits. Exploration for and development of commercially valuable deposits. Field trip required. (3 s.h.)

INSTITUTION: MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PROGRAM: Mineral Resources Engineering and Management

DEPARTMENT: Interdepartmental

DEGREE: Master of Science (M.S.)
Engineer
Doctor of Science (Sc.D.) or Doctor of Philosophy (Ph.D.)

CONTACT: Dr. Herbert H. Einstein
Mineral Resources Engineering and Management Program
School of Engineering
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139
(617) 253-3598

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Mineral Resources Engineering and Management is an interdisciplinary program in which ten departments participate. Included are the departments of Civil, Mechanical, and Chemical Engineering, Materials Science and Engineering, Urban Studies and Planning, Earth and Planetary Sciences, Ocean Engineering, Economics, Management, and Political Science.

The program emphasizes both the practical aspects of mining and minerals processing and policy questions of resource allocation and environmental impact. It comprises four subprograms: exploration, extraction, processing, and resource management. The M.S. student normally takes seventy-five percent of the required work from one subprogram and the remainder from one of the others. Engineer and Ph.D. students, however, usually take one-half of their work from one subprogram and the remainder from at least two of the others. Students taking the program are registered in one of the participating departments and receive their degree from this department.

The primary research facility used is the MIT Energy Laboratory.

PROGRAM REQUIREMENTS

For admission to the program, a student normally seeks admission to the participating department in his/her major field of interest. General requirements for the S.M. and Engineer programs include a bachelor's degree or equivalent from an acceptable college, university, or technical school along with demonstration of ability to accomplish a program of study and research. The Sc.D. and Ph.D. programs normally require entering students to meet the qualifications for a Master's degree before admission. For the exploration subprogram, a background in geology is required and for the processing subprogram, a background in materials science and engineering or chemical engineering is recommended.

Degrees are awarded by the department in which the student is registered. It may be with the department's specification or without specification, depending on the student's program and the department's policy. All degrees require a thesis. The Sc.D. and Ph.D. degrees are interchangeable and the student may select either one.

CURRENT FACULTY, STUDENTS, GRADUATES

There are currently twenty faculty members participating in this program. They are full-time members of participating departments and spend slightly less than half their time in research, as opposed to teaching. Research funding is available through the U.S. Bureau of Mines, the Energy Research and Development Administration, and the Department of Health, Education, and Welfare in the form of mineral fuel conservation fellowships for thesis research.

Currently fifteen students are enrolled in the program, with several of them being career change students from the traditional science and engineering disciplines. Officials estimated that about ten percent of the students are foreign. No specific recruiting is done for this program but the Institute does have a general recruiting program. All students in the program so far have received financial aid in the form of fellowships and research assistantships.

Since the program just began in 1977, there have been no graduates so far.

PROGRAM PROJECTIONS

Expansion of the program is considered to be a good possibility. Officials would like to offer additional courses and bring in more faculty from the participating departments. It is also anticipated that a separate degree in Mineral Resources Engineering and Management may be offered within the next few years.

COURSE DESCRIPTION (SELECTED)

CE 1.72 Groundwater Hydrology - A basic subject analyzing the role of groundwater in the hydrologic system. (3 s.h.)

CE 1.77 Water Quality Control - Analysis of environmental engineering problems in water quality and pollution control technology. Emphasis on predicting the distribution and fate of effluents discharged into lakes, reservoirs, rivers, estuaries, and oceans. (3 s.h.)

CE 1.78 Water Quality Management - Systematic approach to the management of water quality. Identification of major issues and problem areas. Type, sources, and stochastic nature of waste materials and their effect on water bodies. (3 s.h.)

CE 1.811 Environmental Law: Pollution - Review and analysis of common law, legislation, and regulation for pollution control. Focus on programs, analytical and decision-processes for controlling water, air, and noise pollution, and the emission of toxic materials. (3 s.h.)

CE 1.812 Environmental Law: Land Use and the Siting of Facilities- Review and analysis of common law, constitutional law, legislation, and regulation for land use control and the siting of major facilities. Analysis of federal-state-local relationships and allocations of authority; and of uses of federal and state environmental impact assessments. (3 s.h.)

ME 2.284 Water Purification - An introduction to water resources, water quality parameters and pollutants. (3 s.h.)

ME 2.741 Fundamentals of Mining Technology - Essential features of mining operations, beginning with the nature and origins of ore-bodies, the properties of materials, and a study of the geometry of mining in general. This is a design and applications oriented subject which may be advantageously combined with analytical treatment offered in 2.074. (3 s.h.)

ChE 10.39 Energy Technology - Study of the factors determining the design of energy conversion systems. Consideration of energy supply and demand patterns, environmental problems of waste heat and material emissions associated with energy consumption, and energy transportation and storage. (3 s.h.)

ChE 10.72 Seminar in Air Pollution Control - Review of combustion sources of pollution and of criteria and legislation for maximum allowable emission rates. Other relevant topics. (2 s.h.)

ChE 10.771 Seminar in Wastewater Treatment Processes - First third of term devoted to fundamentals of thermodynamics, heat and mass transfer, kinetics, and process design. (3 s.h.)

11.017 Environmental Policy and Controls - Societal control, protection, and abuse of the environment, especially the urban environment, including zoning, building codes, social convention, the real estate market, public investment and pollution controls. Emphasis on learning how to predict and evaluate the effects of different control systems (regulatory, tax, market, and enforced disclosure) in specific cases in order to choose among alternative policies, rather than studying specific current practices. (3 s.h.)

12.33 Petroleum Geology - Origin, migration, and accumulation of petroleum. Other topics of current interest. (3 s.h.)

13.95 Offshore Petroleum Exploration and Development - Discussion of seismic techniques in offshore petroleum exploration followed by analysis of viscous flows in porous reservoirs under a variety of drive mechanisms. An applied terminal subject aimed at graduate and advanced undergraduate students considering careers in or relating to the offshore petroleum industry. (3 s.h.)

17.851 The Domestic and International Politics of Energy - The first part deals with the politics of energy policy and energy choices in the U.S. The political issues associated with energy supply and demand in Western Europe, the Soviet Union, and East Asia; the international response to changes in the world, and other topics. (3 s.h.)

INSTITUTION: MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Engineering

DEGREE: Bachelor of Science (S.B.)
Master of Science (S.M.)
Nuclear Engineer
Doctor of Science (Sc.D.) or Doctor of Philosophy (Ph.D.)

CONTACT: Dr. Norman C. Rasmussen
Head, Department of Nuclear Engineering
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139
(617) 253-3802

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Nuclear engineering at M.I.T. is composed of four degree programs: the S.B., S.M., Nuclear Engineer, and Sc.D. or Ph.D. The graduate programs have been in existence since 1958 and the undergraduate program began in 1975-76 school year.

The undergraduate program is somewhat interdisciplinary in that students are encouraged to take courses from several departments in order to gain broad exposure to engineering and the sciences. Students have considerable flexibility in planning their programs and may either specialize in a particular aspect of nuclear engineering or obtain a broad-based background.

Graduate programs are also flexible, allowing students to plan their own programs of study. Most, however, fall into one of six fields of study that are offered; reactor physics, reactor engineering, nuclear fuel and power management, applied plasma physics, nuclear materials engineering, and applied radiation physics. The S.M. program is one year in length and prepares students for careers as nuclear engineers or for more advanced study. A Nuclear Engineer degree is a two-year professional degree, training students in the practical aspects of nuclear engineering. A Ph.D. program generally takes three to five years to complete and prepares students for advanced research in the field.

Program support facilities include a nuclear reactor, nuclear research labs, and the computer facilities of the MIT Information Processing Center. Students and faculty also have the opportunity to use the facilities of national laboratories such as Brookhaven.

PROGRAM REQUIREMENTS

Requirements for entry into the S.B. program include a high school diploma with a minimum of units (one year of study) taken in specified subjects, including four units of English, two units of algebra, one unit each of plane geometry, physics, and chemistry, and one-half unit of trigonometry. Applicants are required, in addition, to take the Scholastic Aptitude Test and three achievement tests and to have a personal conference with a member of the M.I.T. Educational Council.

Master's and Engiener degree admission requirement include a bachelor's degree or equivalent from an acceptable college, university, or tehcnical school along with demonstration of ability to accomplish a program of study and research. The Sc.D. and Ph.D. programs normally require a student to meet the qualifications for a Master's degree before admission is granted.

Degree requirements for the S.B. include the completion of sixty credit hours in science requirements and seventy-two hours in humanities, arts, and social sciences. After completing these, the students select courses in basic engineering principles including thermodynamics, fluid flow, heat transfer, strength of materials, and computer modeling. In the final two years, a student concentrates in nuclear engineering subjects which include a design course and a thesis required for the degree.

Minimum requirements for the M.S. degree are two semesters of full-time graduate course work plus a thesis. The Nuclear Engineer degree requires four full time semesters of graduate course work, including a thesis concerned with engineering, analysis, engineering design or construction of nuclear facility or device. A student who meets the requirements for the Engineer degree is simultaneously approved for the S.M. degree by the department. The Sc.D. and Ph.D. degree are awarded interchangeably and the student may select either one. Requirements include a general examination in one of the six fields of study offered and an original research investigation which constitutes a contribution of permanent value to science and technology. No time limit is required for completion of the program, however, most students require three to five years.

CURRENT FACULTY, STUDENTS, GRADUATES

There are currently twenty-five faculty members in the Nuclear Engineering Program, and all are involved in both teaching and research. Research funding is available from a number of sources, primarily the Energy Research and Development Administration (ERDA) and the Electric Power Research Institute.

A total of thirty students are enrolled full-time in the undergraduate program and one hundred and fifty full-time students are in the graduate program. The program does attract a few career-change students, primarily physicists. Although no records are kept on ratios of in-state and out-of-state students, approximately one-third of the program enrollment is composed of foreign students. The only recruiting done, is through the distribution of brochures to other colleges and universities. Most students, expecially at the graduate level, are receiving some form of financial assistance. This currently includes twenty-three teaching assistantships, forty-four research assistantships, nine ERDA traineeships, and various other government (domestic and foreign) and private industry fellowships, traineeships and support.

In 1976, thirty-nine S.M. degrees were awarded, along with seven Nuclear Engineer, and twenty-four Sc.D. or Ph.D. degrees. All of these figures represent an increase over previous years and is indicative of the increasing interest in the program. The S.B. program just began in the 1975-76 school year and no figures are available concerning graduates. Of the total number of graduates, about one-third find employment in private industry. Another twenty percent work in government positions, mostly military. Approximately fifteen percent are employed by foreign governments and another fifteen percent go on to further study. The remainder generally work for national nuclear labs in research positions or go into teaching. The primary methods of finding employment are through faculty contacts or the M.I.T. placement service.

PROGRAM PROJECTIONS

With the addition of the undergraduate program in 1975, no further expansion in program or faculty is anticipated for the next several years.

ADDITION INFORMATION

The Nuclear Engineering Department offers a summer program, primarily for industry, on nuclear power reactor safety.

COURSE DESCRIPTION

22.04 Radiation Effects and Uses - Current problems in science, technology, health and environment which involve radiation effects and their utilization. Material properties under nuclear radiations. Medical and industrial applications of radioisotopes. Radiations and lasers in research. Radioactive pollutants and demographic effects. (2 s.h.)

22.08J Energy - Energy from a holistic point of view: provision, rational utilization and conservation, regulation, environmental effects, and impact on other societal sectors. Resources of petroleum, natural gas, coal, nuclear and other energy forms. Technologies of providing energy from these forms. Utilization of energy in various sectors: transportation, industrial, commercial, and domestic, including expecially opportunities for increased efficiency and energy conservation. Regulatory tax, and other institutional arrangements that affect production and use patterns. Environmental costs and opportunities associated with exercising various energy strategies, both existing and proposed. Domestic and international political, strategic, and economic implications. (3 s.h.)

22.37 Environmental Impact of Power Production - An assessment of the various environmental impacts of producing thermal and electric power with currently available thecnology. Impacts compared throughout both the fossil and nuclear fuel cycles. Topics include fuel resources and extraction, power station effluents, waste heat disposal, reactor safety, and radioactive waste disposal. (3 s.h.)

22.80 National Socio-Technological Problems and Responses - A subject designed to acquaint the student with large socio-technological problems and our capabilities regarding them, in ways beyond discipline oriented research. The structure and content of national problems; connectivity between problems and sectors. Review of present organizations at the working level (universities, national laboratories, industrial laboratories, etc.) the extent to which they relate to the decision-making levels, and the extent to which they match or mismatch their programs to the true scale of problems. Recent efforts to make new organizations or to re-orient present ones. Recent debates, programs, and proposals related to energy and the environment used as particular examples. (3 s.h.)

22.81 Energy Assessment - An introduction to the broad field of energy, including technological, social, environmental, economic, and political aspects. Energy provision, transformation, and utilization. Development of energy options for the future, and anlayses of present regional, national, and international energy programs. Intended for graduate students entering specific energy fields or in which energy is important, and who desire a holistic overview. (3 s.h.)

22.913 Graduate Seminar in Energy Assessment - Primarily designed as a communication medium among students conducting research in energy related areas, and as means for obtaining critical evaluation of their ongoing research work. Covers topics ranging from technological comparisons to environmental, social, resource, and political impacts, depending on current student and faculty interest. (2 s.h.)

INSTITUTION: MEMPHIS STATE UNIVERSITY

PROGRAM: Operator Training in Nuclear Reactor Fundamentals

DEPARTMENT: Center for Nuclear Studies

DEGREE: Certificate of Completion and
Academic Credit

CONTACT: Dr. D. W. Jones, Director
Center for Nuclear Studies
Memphis State University
Memphis, Tennessee 38152
(901) 454-2687

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The Nuclear Reactor Fundamentals Training Program provides instruction in reactor theory and fundamentals of nuclear power plant components and operation. It is designed to provide the potential reactor operator with a sound fundamental background in preparation for further technical and specialized training and for the Nuclear Regulatory Commission (NRC) license examination.

The Center for Nuclear Studies has been operational since July of 1974. It is an organizational unit of the Office of Public Service and Continuing Education. The Center's activities are chiefly supported by industrial training contracts, although some state and federal funds have been used for specific purposes. The Center carried out limited applied research in conjunction with the university, and is particularly prepared to carry out design studies and to work in component development. The Center is viewed as a positive link between the university and the industrial community. Most of the students are employed by utilities.

The Nuclear Regulatory Commission has reviewed this program and has found it appropriate for inclusion in an overall reactor operator training program. In this context, it satisfies NRC requirements for fundamentals training.

PROGRAM REQUIREMENTS

The training program consists of approximately seven hundred contact hours of instruction, divided into eleven modules. The first ten modules of the Nuclear Reactor Fundamentals Course is offered primarily at industrial plant sites for training of operator license candidates, but programs may be offered on campus in appropriate instances for specific groups. The final module, "Reactor Operations", is operated at the Center for Nuclear Studies training facilities, with portions conducted at the

Oak Ridge National Laboratory. This section of the program provides hands-on experience in the startup, operation and shutdown of training reactors. A minimum of ten meaningful reactor startups is included in the curriculum.

At least two quizzes are given to students each week, and a two-hour formal examination is given for every thirty-five hours in class. Daily records are kept on all trainees' progress, which are submitted to employing utilities for review. Private consultation and tutoring are arranged for students who fall behind schedule.

There are no formal prerequisites for a utility employee or other potential student for entrance into the program. Officials feel, however, that it is important that participants have had a high school education or the equivalent, with background in mathematics and physics. The Center carries out a testing and screening program to assist utilities in selecting employees who are likely to succeed in the program. An educational specialist and an industrial psychologist perform this function.

The Center also has developed all of its own curriculum materials for this course, and carries out an ongoing evaluation of these materials and test questions. A test question bank is maintained, and records are kept on the usage of each question in tests. Judgement of the quality of each question is based upon student responses.

The University College of Memphis State University recognizes the Nuclear Reactor Fundamentals program as equivalent to thirty-two semester credit hours of experential learning credit. These are applicable toward a Bachelor of Professional Studies degree.

CURRENT FACULTY, STUDENTS, GRADUATES

Six instructors of the Center for Nuclear Studies teach the courses and prepare curriculum materials. They have had six to fifteen years of operating experience, in the military and commercial nuclear plants. These instructors will also teach the planned radiation protection course, which is described in a separate volume of this report.

Two pilot courses were held following the development of the curriculum. Approximately forty students began these courses, some of whom were already working in the nuclear industry; approximately twenty completed these courses. Two additional courses have been held under industrial contracts for persons working within the utilities. Approximately forty persons started these courses, and an estimated thirty-six completed the curriculum.

The faculty of the Center attempts to assist those persons not already employed with utilities in finding employment in the nuclear field. Most persons successfully completing the program are able to secure such employment, nearly all in the private sector. Many students, after completion of this program, take additional reactor operator training that is offered by several industries in preparation for a license.

PROGRAM PROJECTIONS

Whether curriculum changes will be made depends in part upon NRC regulations and on outcomes of the Center's ongoing self-review process. The future number of courses offered and faculty needs are entirely contingent upon the demand for the course by the nuclear industry, and the number of students that enroll.

COURSE DESCRIPTION

Module 1 Basic Mathematics - Reinforces the fundamental techniques of mathematics used throughout the program. Numbers, algebra, calculations, trigonometry, special problems. (2 weeks)

Module 2 Physics-Mechanics - Provides a fundamental background in the principles of classical physics needed for nuclear power plant operation and for pursuit of advanced or specialized training. Measurement; forces and vectors; motion; gravity and free fall; angular motion; work, power and energy; momentum and impulse. (1 week)

Module 3 Heat and Thermodynamics - Provides a fundamental background in the principles of heat transfer and thermodynamics needed for nuclear power plant operation and for pursuit of advanced or specialized training. Thermodynamics, steam and vapor properties, thermodynamic cycles, heat transfer, boiling heat transfer, thermal stress. (2 weeks)

Module 4 Fluid Mechanics - Provides a fundamental background in the principles of fluid flow and associated equipment needed for nuclear power plant operation and for pursuit of advanced or specialized training. Fluid statics, fluid flow, pumps, turbines, piping and valves. (1 week)

Module 5 Electricity - Provides a fundamental background in principles of electricity and electrical equipment needed for nuclear power plant operation, electrical power generating stations, and for the pursuit of advanced or specialized training. Electrostatics, direct current, alternating current, electrical meters, motors and generators, control and protective devices, logic diagrams. (2 weeks)

Module 6 Nuclear Physics - Introduces trainee to basic principles of nuclear physics with special orientation toward reactor power plants. Atoms and matter, electromagnetic waves, radioactivity and particle behavior, nuclear reactions, fission. (2 weeks)

Module 7 Reactor Physics - Provides the background in basic nuclear fundamentals important to reactor operation and design, the terminology used in reactor operation, and special problems in reactor operation and maintenance. Introduction to nuclear reactors; nuclear fission; neutrons, reactions, moderator effects; neutron multiplication process; reactivity; fission product poisons; reactor kinetics; reactor operation, start-up and shutdown; reactor safeguards. (3 weeks)

Module 8 Instrumentation - Provides the fundamental background in the principles of operation and usage of radiation detectors, process instrumentation and reactor instrumentation. Process instrumentation, radiation monitoring instrumentation, nuclear instrumentation. (1 week)

Module 9 Chemistry and Materials of Construction - Provides a fundamental knowledge of chemistry involved in reactor power plants with special emphasis upon water chemistry and the types of materials used in reactor construction. Chemistry, aqueous solutions, chemical processes, materials of construction. (1 week)

Module 10 Radiation Protection - Provides basic instruction in the biological effects of radiation, the techniques of personnel and area monitoring, and a familiarity with regulatory codes. Nuclear radiation; radiological standards, responsibilities and limits; biological effects of radiation; radiation detection and monitoring; radioactive contamination and control; shielding. (2 weeks)

Module 11 Reactor Operations - Provides hands-on experience in start-up, operation, and shut-down of training reactors. Reactor operations start-up manual; reactor instrumentation; reactor start-up, operation and shut-down; 1/M approaches to criticality; temperature effects on reactivity; xenon effects on reactivity; control rod worth; data collection and evaluation. (3 weeks)

INSTITUTION: MOREHEAD STATE UNIVERSITY (MSU)

PROGRAM: Mining Technology

DEPARTMENT: Industrial Education and Technology

DEGREE: Associate of Applied Sciences (A.A.S.)

CONTACT: Mr. Terry Mullins, Acting Director
Mining Technology
Morehead State University
Morehead, Kentucky 40351
(606) 783-5103

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

This two-year program was organized in conjunction with an associate degree program in Reclamation Technology in 1973. Reclamation Technology has had only a small number of students since its inception. The current focus of the Mining Technology Program is on safe methods of deep mining coal.

Initially, it was thought that graduates of this program would be hired as entry level mine workers, when in fact, they are being hired into lower level supervisory positions. The Mining Technology Program is now designed to produce technicians for entry-level management positions with skills in surveying, mine hydraulics, safety and accident prevention, roof and rib control, ventilation, electricity, safety codes, the use of mine machinery, and the handling of explosives. Most typically these graduates are employed as mine supervisors, mine inspectors, and consultants with mining engineering firms.

As a result of its recent inception, this program is trying to build its enrollment. The use of a Mining Enforcement Safety Administration (MESA) mobile classroom unit has been the most effective means of recruiting graduating high school students. This same MESA unit has been extremely useful for use by MSU classes in the field.

PROGRAM REQUIREMENTS

In order to enter this program, prospective students must be eligible for admission to the university. Students whose past academic performance is marginal may be required to take remedial course work and will have access to tutorial services.

Many opportunities for field experience exist for students in this curriculum. While Morehead itself is not a coal production area, eastern Kentucky is the largest regional producer of coal in the nation, and mines are located within a short distance of the campus. Most courses have been organized in a coal deep mining context to reinforce the students in all possible aspects of the industry. Forty-five semester hours are courses which in one form or another are related to mining, and an additional sixteen semester hours are taken in general requirements. These are not entirely unrelated to the Mining Technology Program; two examples are Physical Geology, and Land Conservation and Forest Management.

There is no formal internship at this time. Students may coop through the university during the summer. Financial assistance is available through a MESA grant in amounts varying up to a maximum of five hundred dollars, dependent upon a student's need; these are not designated for tuition. At the time of this report, forty-four students were receiving aid from MESA. Students may also take advantage of institutional grants and aid (i.e., work study, etc.).

CURRENT FACULTY, STUDENTS, GRADUATES

There is one full-time and one half-time faculty, who are exclusively responsible for mining technology. Additionally, there are twelve people who have input by way of course instruction or by advisory assistance. A MESA grant made provision for one full-time instructor (who is acting as director), and one part-time instructor.

There are seventy-seven Kentucky residents and two out-of-state students enrolled in this associate program. Although most students have enrolled directly from high school, a small number of people from the mining industry enroll. There is now an effort to increase the enrollment. There have been twenty-one graduates between May of 1973 and May of 1977.

The Placement Office on campus has been effective in finding appropriate positions for graduates. Another common practice is that of faculty members helping students to locate positions through professional contacts. There has been no formal follow-up study conducted on graduates yet; however, one is being prepared, the results of which will be available by the time this report is in print. Even though the study is incomplete, some limited information is available. Of twenty-one graduates, two are mine foremen, fourteen are involved in mine production work, three are employed by mining engineering companies, one is unemployed, and one was hired as a full-time mining technology instructor at MSU (now the acting director).

PROGRAM PROJECTIONS

The first change in the program which is expected to occur before long is the addition of a mandatory summer internship. This will require a commitment from local industry for placement of the students. Officials hope to expand the Mining Technology Program to include a four-year degree option, as well as maintain the two-year program. There is a need to provide professional certification opportunities to students, and this is expected to occur soon. In response to surface mining legislation there will be an option to study surface ("strip") mining techniques in the near future. The first year of courses will be a core curriculum common to both deep and surface mining students' curricula. The second year students will select a specialization in one or the other.

COURSE DESCRIPTION

MT 101 Fundamentals of Mine Safety Engineering - An overview of areas of technical and safety problems inherent in the production of coal. (3 s.h.)

IE 103 Technical Drawing I - A study of principles and techniques of communicating ideas by graphic representation. (3 s.h.)

CT 102 Surveying I - Introduction to Surveying Methods equipment. (3 s.h.)

MT 102 Mining Surveying - Use of transit in above-ground and underground surveying. Techniques related to location of benchmarks, plotting of shafts and passageways. Safety precautions use in mine surveying. (3 s.h.)

MT 103 Mining Drafting - Adaptation of basic drawing and drafting skills to mine layout and design. Emphasis upon accurate pictorial interpretation of measurement and layout and upon development of skills used. (3 s.h.)

CT 103 Materials Testing - An investigation of materials science including typical physical destructive and nondestructive testing procedures. Reviews ASTM and other standard agencies. (3 s.h.)

IE 240 Basic Electricity - Ohms Law, series and parallel circuits, Kirchofts Laws, magnetism, electrical measuring instruments, transformers, inductance, capacitance, introduction to electronics. (3 s.h.)

IE 139 Internship - Each student will be phased through work experiences related to the subject matter covered during the first two semesters. She/he will keep a detailed log of experiences and activities and will develop a formal report at the end of the internship. (4 s.h.)

MT 201 Mining Equipment, Controls, and Applications - Analysis of various types of mining equipment including design, function, methods of control, applications, and safety of operation. (3 s.h.)

MT 202 Mine Design, Ventilation, and Drainage - Analysis of approaches to mine design, methods and purposes of ventilation and drainage. Safety factors in design, ventilation and drainage are stressed. (3 s.h.)

MT 203 Mine Electrical Systems and Installation - Analysis and function of mine electrical systems. Design and installation of safe systems, preventative maintenance, and inspection as safety measures. (3 s.h.)

GEOS 100 Physical Geography - Weathering, erosion, vulcanics, diastrophism, common minerals and rocks, topographic maps, geologic features and processes. (3 s.h.)

IE 160 Introduction to Power and Fluid Mechanics - Beginning instruction in energy sources and fluid systems. Steam engines, steam turbines, diesel engines, spark-ignition engines, exhaust emissions are studied. (3 s.h.)

MT 204 Coal Preparation and Waste Disposal - The process of cleaning, sizing, and mixing coal. Analysis of methods of safe disposal of wastes and by-products from coal preparation. (3 s.h.)

MT 205 Mining Laws and Management - Study of mining laws and their relationship to mine management and operation. Analysis of state and federal safety codes, their interpretations, and applications. (3 s.h.)

MT 206 Mine Systems Technology - Engineering approach to mine systems design and operation. Mine technicians will work with and understand the mine engineer in the planning, development, and installation of safe, effective, and efficient mine systems. (3 s.h.)

AG 207 Land Conservation and Forest Management - Principles of land resource conservation. Special emphasis on land and water conservation by reforestation of areas denuded by strip mining. (3 s.h.)

INSTITUTION: MUSKINGUM AREA TECHNICAL COLLEGE

PROGRAM: Petroleum Engineering Technology (Oil and Gas Well Drilling and Management)

DEPARTMENT: Division of Engineering and Science

DEGREE: Associate of Applied Science in Petroleum Engineering Technology
One-Year Certificate in Petroleum Engineering Technology

CONTACT: Mr. Charles Woolf, Division Chairman
Division of Engineering and Science
1555 Newark Road
Muskingum Area Technical College
Zanesville, Ohio 43701
(614) 454-2501

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

This innovative one- and two-year college level program of classroom and laboratory and field experiences prepares a student for oil field exploration; supervision of rig construction, drilling, oil field services, and crude petroleum production; and work as a technician in direct support of the engineer and geologist in the oil industry. Begun in 1975-76, the Petroleum Engineering Technology program at Muskingum Area Technical College recognizes the need for competent technicians in oil and gas industries and in state and federal government agencies. Curriculum oversight is the responsibility of an advisory committee composed of people from the petroleum field.

The course of study includes mathematics, chemistry, physics, petrology, sedimentation, and geophysics as applied to the recovery and use of oil and gas. Students intern during the summer months in employment related to this technology; their work counts as college credit and is supervised by the faculty.

The program maintains a gas/oil/water separator and equipment to analyze earth cores to determine rock composition. In field work involving gas exploration, MATC has the cooperation of industry which permits on-site visits by students. Schlumberger, a well-logging service, also supplies textbooks. The land-lease class has access to the county recorder's office and the files there.

PROGRAM REQUIREMENTS

The One-Year Certificate in Petroleum Technology requires completion of 62 quarter hours and enables students to exit directly into employment or continue into the second year of study without disruption or loss of credit. The Associate of Applied Science degree demands 110 quarter hours. Admission to MATC requires a high school diploma or its equivalent. College prep math is recommended for the Engineering and Science Technologies including Petroleum Engineering.

CURRENT FACULTY, STUDENTS, GRADUATES

One full-time faculty member serves 18 first-year and 10 second-year students in this program (FTE=approximately 21.5). Of the nine Associate Degree graduates from the program to date, six are employed in technology, two found jobs outside of technology, and one is classified as available for employment (not necessarily unemployed). The program has its own placement officer, and the internship and advisory committee also help in locating jobs for graduates.

Financial support, aside form the summer internship, is provided through Basic Educational Opportunity Grants, Ohio Instructional Grants, national and state loan programs, and college work-study. Roughly one-third of MATC students are given some form of aid. Further schooling is limited to those schools that accept A.S. degree credits from Muskingum, and the programs at higher degree levels in Petroleum Engineering are not plentiful.

PROGRAM PROJECTIONS

While the job market in the geographical area of Ohio served by Muskingum Technical is fast becoming saturated with petroleum technology students, which may result in some curriculum revision, the employment forecast for technicians, oil field workers, and rig crews continues to be excellent. Faculty note, however, the need for a small drilling rig model and models in logging in order to provide students with top quality practical training. The career-orientation of this program must be matched by industrial and governmental awareness of the capabilities of the one- and two-year graduates who have a sound scientific working background upon completion of this program. The single faculty member--one more may be added within five years--has at least three to four daily preparations in addition to equipment set-up time pressures; school personnel maintain that release time from teaching is essential for staff members working under these conditions but that release time demands monies which are not anticipated in the immediate future.

COURSE DESCRIPTION*

One-Year Certificate and A.S. Degree courses:

PET 101 Introduction to Petroleum Technology - An orientation into the field of petroleum. History and future possibilities; exploration methods; oil field development; well completion methods; and conservation policies. (3 q.h.)

NRC 121 Technical Drawing and Mapping - The principle objectives are to introduce a basic understanding of orthographic projection, ability to understand detail and assemble working drawings and to produce clear, legible, and neat drafting work using current drafting tools and techniques. (3 q.h.)

ENV 241 Occupational and Industrial Health - An investigation of the procedures and attitudes required so that man may safely work in the vicinity of industrial processes and equipment. Topics include occupational and industrial safety requirements, equipment design and safety, processing atmosphere and health and industrial health inspection procedures. (4 q.h.)

PET 161 Petroleum Drilling Methods - Principles of drilling methods and drilling systems, including drilling mud, drilling a straight hole, casing and cementing, testing and completing, controlled directional drilling, open hole fishing, blow out prevention, and maintenance of surface equipment. (3 q.h.)

PET 211 Rig Construction and Drilling Operations - Rotary drill series including topics on: the bit, the drill system, rotary kelly and swivel, the blocks and drilling line, the hoist, power and power transmission, circulating systems, auxiliaries, safety on the rig, diesel engines and electric power, and mud pumps and conditional equipment. (3 q.h.)

SUR 221 Surveying I - An introductory course in land surveying including level and transit nomenclature, instrument set-up, and field applications of horizontal measurements. Basic procedures in keeping accurate field notes. (4 q.h.)

PET 221 Oil Field Services - Well servicing and workover topics including well logging methods, well completion methods, artificial lift methods, production rig equipment, well servicing and repair, control of formation pressure, fishing tools and techniques, well stimulation treatment, and well service profitability. (3 q.h.)

GEOL 101 Geology - Introduction to physical and historical geology with lab and field work emphasizing rock and mineral identification. (3 q.h.)

PET 241 Petroleum Production - Theory and design of lift systems, design and selection of surface systems for the separation treatment and storage of oil, water, and gas. Included is field handling of natural gas, operation of electrified and automatic leases, oil pipeline pumping station operation, flow measurement, positive displacement pumps, and oil field safety. (3 q.h.)

ENGR 200 Internship - Supervised work experience required for engineering students. Includes student applying for job in related area, on-the-job supervision, scheduled visits by coordinators, periodic evaluations. (3-7 q.h.)

ENGR 299 Seminar - Course taken in conjunction with Internship. Includes discussion of students' intern experiences, principles of employment practices, and improvement of employee attitudes. (3 q.h.)

A.S. Degree courses only:

PHYS 101 Mechanics - Topics covered are: inertia, rotational dynamics, torque, linear and rotational equilibrium, levers, systems of units, graphs, error analysis, scientific notation, kinematics, velocity, acceleration, Newton's Laws, force, mechanical energy, work, power, conservation of energy, and special instrumentation. The analytical balance and pile driver

PET 111 Petroleum Geology - This course consist of lab and field work that emphasize the identification of rocks (especially sedimentary) and minerals and the interpretation of physiographic features. Sub-surface mapping is also emphasized. Course includes formation and evaluation of oil and gas trap types, formation of petroleum, and migration. (4 q.h.)

PET 271 Mineral Rights and Leases - Research course covering laws of land ownership, mineral rights, royalties and leases, transfer of property, guarantees of title, deed platting, eminent domain, deeds, writing and deed descriptions, and the use of tax and topographic maps in the securing of leases. (3 q.h.)

PHYS 104 Atomic and Nuclear Physics - Topics covered are: electric charge, electric field, electric forces, types of radioactivity, detection of radioactivity, ionization, half life, atomic models, energy levels, absorption and emission of light, fluorescence, and applications in industry and medicine. The cathode-ray tube, Geiger counter, and fluorescent lamp will be utilized. (3 q.h.)

PET 151 Oil and Gas Reservoirs - Study of physical properties of petroleum reservoir rocks emphasizing porosity, fluid saturation, and permeability and study of thermodynamic behavior of naturally occurring hydrocarbon mixtures including core analysis, porosity, and permeability determinations. (4 q.h.)

PET 201 Hydraulics - Basic hydraulic engineering including hydrostatics, liquid pressure, viscus and turbulent flow, fluid friction, use of pipe conduants and piping systems for both liquids and gases. (3 q.h.)

PET 231 Oil and Gas Well Completions - Well completion methods emphasizing casing, cementing, acidizing and hydraulic fracturing. Emphasis is placed on the various well logging methods, electric, and nuclear including practice for complete log analysis. (3 q.h.)

PET 261 Application in Petroleum Technology - Special field problems and seminar discussion of the most recent technical developments in petroleum engineering with special emphasis on engineering problems of petroleum and natural gas exploration, production, transportation, including drilling and production design, well logging petroleum measurements, and producing mechanisms. (4 q.h.)

PET 281 Petroleum Property Management - Economic evaluation of wells, fields, and potential in addition to studies of factors which influence industrial organization, securities, and values of oil and gas properties. Preparation of valuation reports, taxation, petroleum accounting, regulation petroleum production. (4 q.h.)

*Courses are listed in the sequence taken by a student.

INSTITUTION: OAK RIDGE ASSOCIATED UNIVERSITIES (ORAU)

PROGRAM: Special Training

DEPARTMENT: Manpower Education and Research Training Division (MERT)

DEGREE: Certificate of Participation

CONTACT: Mr. Roger Cloutier
Oak Ridge Associated Universities
P.O. Box 117
Oak Ridge, Tennessee 37830
(615) 483-6352 (ext: 263)

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Oak Ridge Associated Universities got its start in 1946, at a time when the south was largely agricultural. ORAU then determined the appropriate role for it to assume was one of scientific leadership, so it began as a center for the diffusion of scientific and technical knowledge. Since then, southern universities have made substantial gains and now have rich and varied scientific facilities and intellectual resources. Responding to this high level of sophistication, ORAU's purpose evolved to be the application of the resources of member institutions to the critical scientific and technical problems facing society today.

The ORAU Council is composed of one representative from each of the forty-five southern universities (includes University of Puerto Rico) which comprise this consortium. In 1975, a meeting of the Council determined that three themes would lay the foundation for ORAU activities - energy, health and environment. This body sits in review of all programs offered by ORAU.

In 1974, the Institute for Energy Analysis was formed to provide broad, critical, informed analyses of energy problems and also to assess alternative solutions as the bases for rational energy policy formulation. The Museum Division is based in the three-year-old American Museum of Atomic Energy, and it conducts national education and information programs to improve the public understanding of energy and its environmental effects. The Energy Education Division operates traveling high-school programs called "Energy Today and Tomorrow" and "This Atomic World." Public information workshops are conducted out of this office regularly.

The Medical and Health Sciences Division's purpose is to conduct research in biomedical and environmental medicine to help meet the need for understanding and effectively treating occupational health hazards of new energy technology. Immunobiology, biochemistry, radio pharmaceuticals, human radiation biology, and epidemiology are the main research areas. The Radiation Emergency Assistance Center/Training Site (REAC/TS) is housed in a specially equipped emergency wing of the Oak Ridge Hospital. Its function is to treat persons who are accidentally exposed to radiation, to provide consultant services; and to offer short, intensive training courses in detection, monitoring, and biological effects of radiation (description appears in this volume).

The Manpower Education, Research, and Training Division (MERT) is a recent consolidation of the University Programs Office, Special Training Division, and the Manpower Development Division. Its main concern is with the skilled and professional manpower needed to effectively deal with the nation's energy and related health and environmental problems.

University Programs offers college and university faculty members and students the opportunity to conduct research and development using the facilities at the Oak Ridge National Laboratory (ORNL). More than thirteen-hundred faculty members have taken advantage of summer research appointments since this program got under way in 1946. Laboratory Graduate Participation, established in 1948, has allowed more than three-hundred master's and doctoral candidates in the sciences, engineering, and mathematics to do research for theses or dissertations. Ten-week summer appointments are open to seniors in college who are majoring in engineering, mathematics, and the natural sciences. Over thirteen-hundred students have participated in research projects through this program. In contrast to bringing students and faculty to the laboratory, the Traveling Lecture Program takes professional researchers to the classroom to lecture and participate in colloquia and conferences.

Training and research are the primary activities of the Manpower Development Division. Training and Technology (TAT) began in 1966 and has since prepared nearly four-thousand unemployed or underemployed individuals for the industrial work force with a job placement rate of 90 percent for graduates. Professional Training programs at ORAU are designed to reflect U.S. training needs, particularly those related to energy. These programs were organized in 1948 to provide professional training for scientists and engineers planning to use radiation and radioactive materials in their research. Since that time, changes have been made in keeping with national priorities. The Faculty Institute Program provides professional training in energy-related areas of current national importance to college and university faculty members. The institutes are designed to respond to the needs of the academic community and to relate to the mission of the Department of Energy. Topics include energy research and development, energy conservation, and environmental health and safety. The lectures, laboratories, and tours of related facilities expand the expertise of the faculty participants who then improve and update the energy programs in the curriculum at their home institutions. Recent topics have dealt with energy sources for the future, biological applications of radiation, nuclear power safety, energy production and social sciences, and radiotracer techniques in ecology.

Special seminars, workshops, and training programs are conducted to assist DOE and its contractors in training professional employees. The programs, lasting a few days to a few weeks, are designed to present the results of recent scientific and technological advances related to energy, or the fundamentals required to evaluate energy and environmental problems. The programs include lecture, laboratory, and field trips. This training effort represents a significant continuing education effort by DOE and its contractors to increase employee proficiency.

The major objective of the energy-related programs for students/faculty is to encourage college students to enter and remain in scientific disciplines relating to the nations energy effort. This is accomplished by bringing students and their faculty to Oak Ridge to engage in state-of-the-art scientific activities of interest to DOE. This program has been most attractive to the smaller schools which have neither the lecturers nor laboratory equipment available at ORAU and in the Oak Ridge area. Typical class topics include the examination of samples from different stages of the energy conversion process. X-ray fluorescence and neutron activation analysis are used to analyze coal, iron, fly-ash, oil, etc.

Professional Training also conducts a ten-week health physics course for the U.S. Nuclear Regulatory Commission. The University of Tennessee Resident Graduate Program makes graduate-level courses available to DOE employees and its contractors at the MERT Division facilities in the evening hours.

PROGRAM REQUIREMENTS

The time and duration of the student/faculty visit are made by arrangement with the faculty member in order to minimize academic conflicts. A schedule of training activities is generated to meet the specific needs of the class.

Applications for participation in the Summer Faculty Institute must be accompanied by a letter of recommendation and will be ranked according to the applicant's qualifications and need for the program as judged by a committee of ORAU and DOE representatives.

A five-week Applied Health Physics course is open to qualified professionals from private nuclear industry, governmental agencies, and educational institutions. Prerequisites for attending this program are a bachelor's degree or some health physics experience.

CURRENT FACULTY, STUDENTS, GRADUATES

There are twenty persons who make up the scientific faculty at MERT, seven of whom are fully involved with Professional Training.

Students come from varied backgrounds. Commonly they are from educational institutions, from government and state agencies, and from the private nuclear industry. Course sizes are limited due to the laboratory orientation of most offerings. Certificates of participation are awarded upon completion of each course.

PROGRAM PROJECTIONS

This description is in no way complete with regard to all of ORAU's activities, it is a sampling. Programs will continue to be responsive to technological advances and the level of skill requirements for utilization of such technologies.

COURSE DESCRIPTION (SELECTED)

Energy Production and the Environment - Introduction to forms of energy production now in use and those under consideration. Measurement of impact of energy production on the environment. Modeling as a tool for evaluation of alternate environmental costs of each energy technology. Fossil fuels, nuclear, geothermal, solar, oil-shale, solid wastes, hydrogen are considered. Transport of energy. Alternatives to energy growth. Maximum enrollment: Sixteen. Duration: 2 weeks.

Biological and Ecological Applications of Radiation - Demonstration of uses of radiotracer techniques in biological and ecological studies. Topics include radiation physics, gamma-ray spectrometry, tracer techniques, liquid scintillation counting, activation analysis, x-ray fluorescence analysis. Applications topics include static and dynamic studies in biological and ecological systems. Emphasis throughout on radiation safety. Maximum enrollment: sixteen. Duration: 3 weeks

Energy Options for the Future - Overview of the nation's current energy problems and the various options for immediate and longer range solutions. Currently available energy sources, such as fossil, hydro, and nuclear are considered, as well as prospective resources such as solar, geothermal, thermonuclear, and breeder reactors. Maximum enrollment: twenty-four. Duration 2 weeks.

Energy Conservation: Theory and Practice - Potential benefits of energy conservation in the home, transportation, agriculture, and industry. Theory and practice of energy conservation are stressed. Simple techniques for measuring energy consumption and methods for evaluating the effectiveness of energy conservation practices. Examination of the rate of State and Federal legislation and public education on energy conservation. Maximum enrollment: twenty-four. Duration: 2 weeks

Nuclear Power Safety - Introduction to safety measures taken in construction and operation of nuclear power plants. Emphasis on evaluation of Environmental Impact Statements and Safety Analysis Reports. Review of recent reactor safety studies made by ERDA, NRC, APS, and others. Maximum enrollment: twenty-four. Duration: 1 week

Health Physics and Radiation Protection - A special four-hundred hour course emphasizing the fundamentals of health physics, the problems and practices in providing radiation protection, the mechanism of radiation damage, and methods and procedures for evaluating radiation hazards. Considered to be excellent preparation for the American Board of Health Physics Examination. Maximum enrollment: twenty-four. Duration: 10 weeks.

INSTITUTION: OREGON STATE UNIVERSITY

PROGRAM: Nuclear Engineering and Nuclear Engineering Technology

DEPARTMENT: Nuclear Engineering

DEGREE: Bachelor of Science (B.S.) in Nuclear Engineering Technology; Bachelor of Science (B.S.), Master of Science (M.S.) in Nuclear Engineering, Ph.D. in Nuclear Engineering (new program)

CONTACT: Dr. Chih Wang
Director, Radiation Center and
Institute of Nuclear Science and Engineering;
Head, Department of Nuclear Engineering
Oregon State University
Corvallis, Oregon 97331
(503) 754-1133

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The Oregon State University School of Engineering grew out of a department which was established in 1889. The nuclear engineering and nuclear engineering technology programs were established in 1971 and 1972. Currently, these programs lead to a variety of degrees including the Nuclear Engineer (N.E.) and Doctor of Philosophy (Ph.D.) degrees. For the purpose of this narrative, however, the Bachelor of Science (B.S.) and Master of Science (M.S.) in nuclear engineering, and the Bachelor of Science (B.S.) in nuclear engineering technology are reviewed herein.

The nuclear engineering program has been designed to provide well-trained personnel primarily for the nuclear power industry. These graduates also provide expertise to the nuclear energy industries in the areas of nuclear facility design, and research and development. The major emphasis is on the application of scientific principles to both design and operation of nuclear installations. Nuclear engineers graduating from these programs receive a broad background in reactor physics, nuclear instrumentation, control systems and regulation and safety of nuclear operations.

The nuclear engineering technology program specifically encompasses the baccalaureate level of study. Graduates of this program are well-prepared to enter the field of nuclear power generation. The major emphases placed on this program include the areas of safety regulations, plant licensing, operational requirements, and radiation protection. The technologist is trained to support and implement the conceptual designs and programs of the engineer.

Excellent facilities and opportunities are available for research and instructional purposes at OSU. Research agencies include, in partial listing, the Radiation Center, and the Nuclear

Science and Engineering Institute. Located at the Radiation Center is a TRIGA-II research nuclear reactor.

The Department of Mechanical Engineering conducts supporting energy research activities in the areas of coal, solar energy, wind energy, geothermal and biomass energy. These activities, while conducted through a different department are of significant interest to the nuclear energy community at OSU.

Financial assistance is available to both undergraduate and graduate students at OSU. This aid takes many forms including long-and short-term loans, assistantships, fellowships and scholarships.

PROGRAM REQUIREMENTS

Admission to the Oregon State University programs in nuclear engineering and nuclear engineering technology, is accomplished by means of acceptance by the university. The graduate student must, in addition, seek entrance to the nuclear engineering programs through the Graduate School.

The requirements for the Bachelor of Science in nuclear engineering candidate, involve successful completion of four years of study, normally. In the first two years this student will accomplish 27 quarter hours in calculus and English; 53 quarter hours of chemistry, physics, engineering, physical education, and electives; and, 22 quarter hours of nuclear engineering.

During the second two years, the student will complete another 102 quarter hours which includes: 64 quarter hours of engineering, mathematics, chemistry and electives; and, 38 quarter hours of nuclear engineering which includes NE 407, 420, 421, 422, 423, 441, 442, 461, 462, 463, 464, 465, and 481.

The requirements for the Bachelor of Science degree in nuclear engineering technology vary from those above, substantially. This student must successfully complete 192 quarter hours (as compared to the 204 quarter hours detailed above). Normally, this curriculum also requires four years or 12 quarters of academic course work. Students pursuing the B.S. degree in nuclear engineering technology must complete the following requirements: 80 quarter hours of math, physics, chemistry, writing, and electives; 30 quarter hours in systems, mechanical technology and physical education; and, 82 quarter hours of nuclear technology courses.

The Master of Science candidate must successfully complete a program of study totaling not less than 45 term (or quarter) hours which includes a thesis and courses approved for graduate credit. An oral final examination is required of every master's degree candidate. Under certain conditions and with the approval of the appropriate faculty members, a thesis may be optional.

CURRENT FACULTY, STUDENTS, GRADUATES

The current faculty allocated to these nuclear programs includes nine full-time teaching personnel. Of the nine, eight are considered to be cost-centered.

Enrollment at the baccalaureate level consists of a total of 160 full-time students. Of these, approximately 66% (or 106) are nuclear engineering students, and the remaining 54 are nuclear engineering technology students. At the graduate level, there are 28 male students involved in the master's nuclear engineering program.

Graduates of the programs average approximately 20 annually in nuclear engineering and 10 annually in nuclear engineering technology, at the baccalaureate level. Approximately five students per annum are awarded the Master of Science in nuclear engineering. Approximately 10% of those students receiving the Bachelor of Science, elect to pursue the master's degree.

PROGRAM PROJECTIONS

The faculty associated with these nuclear program, anticipate program growth and expansion over the next few years. The program is limited, however, at present in the number of students that are allowed to matriculate.

No growth in the faculty is expected, at least in the near future. The faculty administration have proposed a new baccalaureate program for 1978-79. The program will offer a Bachelor of Science degree in radiation protection engineering technology.

COURSE DESCRIPTION (selected)

Nuclear Engineering Undergraduate courses:

NE 101, 102 Nuclear Engineering Orientation - Concepts and problems in nuclear engineering. (3 q.h. each)

NE 103 Introductory Nuclear Engineering - Broad look at nuclear industry including principles of reactors, uses of nuclear energy. (3 q.h.)

NE 201 Nuclear Energy Fundamentals - The building blocks of atomic nuclei; mass-energy equivalence and nuclear binding energy, radioactivity, fission, fusion, nuclear energy units. (3 q.h.)

NE 202 Nuclear Radiation and Matter - Interaction of radiation and matter. (3 q.h.)

NE 203 Nuclear Radiation Detection and Measurement - Principles and mechanisms underlying nuclear radiation detection and measurement. (3 q.h.)

NE 309 Social Problems in Nuclear Energy - History of nuclear energy; early discoveries. (3 q.h.)

Graduate and Undergraduate courses:

NE 420 Introduction to Nuclear Reactor Analysis - Basic principles of nuclear reactors covering the fundamentals of steady state and transient behavior. (3 q.h.)

NE 421, 422, 423 Nuclear Reactor Analysis and Computation - Mathematical analysis of the behavior of nuclear reactors based upon physical models. (3 q.h. each)

NE 441, 442 Nuclear Reactor Experiments - Experiments using the TRIGA reactor. (3 q.h. each)

NE 461 Reactor Thermohydraulics - Heat transfer and fluid flow analysis of reactors, core heat removal. (3 q.h.)

NE 462 Power Generation - Descriptions, operating characteristics, and power generation in boiling water; pressurized water, gas-cooled, and fast reactor systems. (3 q.h.)

NE 463 Reactor Design - Numerical and analytical calculations and design of components and systems within a nuclear power plant. (3 q.h.)

NE 464 Reactor Safety Engineering - Pertinent federal and state regulations regarding nuclear safety sources and quantities of radioactive material. (3 q.h.)

NE 465 Nuclear Fuel Cycle - Processes in nuclear industry which deal with exploration, mining and purification of uranium and thorium; conversion to special compounds, enrichment; fuel fabrication, reactor fuel storage, shipment, reprocessing, and waste management. (3 q.h.)

NE 481 Nuclear Materials - Role of Material science in a nuclear reactor. (3 q.h.)

Graduate courses:

NE 511, 512, 513 Advanced Nuclear Reactor Analysis - Mathematical study of behavior based upon certain approximate physical models. (3 q.h.)

NE 521 Reactor Environmental Problems - Federal and state regulations concerning environmental effects of nuclear power plants; development of the analytical techniques for calculating effects of release of gaseous and liquid radioactive effluents, effects of thermal discharges, atmospheric dilution and dispersion, and cost-benefit studies. (3 q.h.)

NE 522 Reactor Safety Problems - Outstanding reactor safety problems such as those addressed in Safety Analysis Reports. (3 q.h.)

NE 523 Advanced Reactor Design - Advanced analysis and design of nuclear power systems. (3 q.h.)

NE 531 Nuclear Reactor Kinetics - Time behavior of nuclear reactors; development of kinetics equations, reactor core control theory, reactivity feedbacks. (3 q.h.)

NE 532 Reactor Economics - Engineering economic analysis of power reactors and nuclear fuel cycles. (2 q.h.)

NE 534 Power Reactor Dynamics - Stability and control of power reactor systems, thermohydraulic and power-demand feedbacks, stability of different reactor types, nuclear system control practices and their analysis. (3 q.h.)

NE 535 Nuclear Reactor Burnup _ Theory and computation of isotope and reactivity changes during operation of a nuclear power reactor. (2 q.h.)

NE 552, 553 Computational Methods for Nuclear Reactors - The application of digital computers to problems in nuclear engineering. (3 q.h. each)

NE 581 Selected Topics in Reactor Theory - Fast reactor physics, advanced reactor thermohydraulics, advanced numerical techniques in nuclear reactor, applications, advanced reactor kinetics and dynamics. (3 q.h.)

NE 582 Selected Topics in Advanced Nuclear Systems - Fusion systems including magnetic confinement, laser fusion, materials, and engineering problems in fusion. (3 q.h.)

NE 583 Selected Topics in Nuclear Energy - Nuclear materials safeguards, isotope separation methods, advanced nuclear waste management, comparative risks and benefits in nuclear energy. (3 q.h.)

Nuclear Engineering Technology courses:

NT 101, 102 Nuclear Engineering Orientation - Concepts and problems in nuclear engineering. (3 q.h.)

NT 103 Introductory Nuclear Engineering - Broad look at nuclear industry. (3 q.h.)

NT 201 Nuclear Energy Fundamentals - The building blocks of atomic nuclei, mass-energy equivalence and nuclear binding energy, radioactivity, fission, fusion, nuclear energy units. (3 q.h.)

NT 202 Nuclear Radiation and Matter - Interaction; nuclear reactions and transmutations, ionizing radiation, chemical effects of radiation, effects on solids, biological effects. (3 q.h.)

NT 203 Nuclear Radiation Detection and Measurement - The principles and mechanisms of nuclear instruments. (3 q.h.)

NT 230 Nuclear Analysis - Application of basic concepts and methods of science and engineering to the analysis of problems encountered in nuclear technology. (3 q.h.)

NT 301, 302, 303 Elementary Reactor Engineering - Nuclear power systems with emphasis on the reactor and its associated control and instrumentation; properties of reactor materials including strength of materials and their relationship to design, corrosion of materials and its relationship to long-term operation. (3 q.h. each)

NT 311, 312 Radiation Protection - Basic principles with particular emphasis on radiation protection instrumentation use and calibration, radiation dosimetry, shielding for radiation protection, design of radiation monitoring programs, radiation protection equipment and techniques, radioactive waste management, biological effects of radiation, transportation of radioactive materials. (4 q.h. each)

NT 411 Nuclear Rules and Regulations - The regulatory phase of the nuclear field. (3 q.h.)

NT 431, 432 Nuclear Power Plant Technology - Technological aspects of nuclear power plants with emphasis on light water reactors, high temperature gas-cooled reactors, and liquid metal fast-breeder reactors. (3 q.h. each)

NT 433 Nuclear Quality Assurance - Quality assurance pertaining to nuclear plant construction and operation. (2 q.h.)

NT 491, 492 Nuclear Technology Experiments - Operation of the TRIGA reactor for steady-state and transient experiments and basic reactor physics experiments. (3 q.h.)

INSTITUTION: PIKEVILLE COLLEGE

PROGRAM: Mining Technology

DEPARTMENT: Mining Technology Department

DEGREE: Associate in Mining Technology

CONTACT: Dr. Maurice E. Bailey, Director
Mining Technology
Pikeville College
Pikeville, Kentucky 41501
(606) 432-3161

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

This two-year program was started in 1971 in response to the Federal Coal Mine Health and Safety Act of 1969, with its first graduates in 1973. Mine safety is now, as it was in its inception, the primary focus of this program. The county in which Pikeville is located is the largest coal producing area in the U.S. which is an important aspect of the internship implementation.

The curriculum is designed so that each course is applied to underground coal mining technology and in that way reinforcing the student's expertise in all possible areas of mining. Because of stringent time requirements, there is no option for taking electives in various other departments. Students who complete this degree will be qualified as aides to mining engineers, mine supervisors, mechanics, surveyors or designers in engineering offices, mine inspectors, or broadly, mine technologists.

While the primary effort in this department is given to instruction, some research activity exists in cooperation with the University of Kentucky's Institute of Mines and Mineral Resources in Lexington. Additionally, the excellent cooperation with the MESA District Office, which is housed on the adjacent property to Pikeville College, has added significantly to the effectiveness of the program.

PROGRAM REQUIREMENTS.

Each prospective student must have a high school diploma or its equivalent in order to enter this program. Applicants should have a good understanding of the underlying principles of high school chemistry, math, and physics. Students must follow a rigid sequence of course offerings leading to an Associate in Mining Technology degree. Each student must take sixty-nine semester credits of courses in the classroom, in addition to a twelve semester credit summer internship in mining for which students receive pay.

Extensive mining in the Pikeville area insures ample opportunity for on-site mine visitation and summer internship placements. Local mines are also a prime consumer of graduates of this program. Likewise, graduates of the program have found employment in mines in western Kentucky, Illinois, West Virginia and Virginia.

Each student enrolled receives financial assistance from the Mining Enforcement Safety Act (MESA). This grant pays the full cost of students' enrollment except for tuition which in 1977 was $140.00 per academic year. A unique feature of this grant is that many of the conventional steps involved in funding of this nature are eliminated. The Director merely submits a bill to MESA, who in turn sends Mining Technology the full amount of the bill.

During the course of the program students will have the opportunity to qualify for nineteen possible professional certificates; these are: First Aid Methods, Mine Fires and Explosions, Principles of Mine Rescue, Use of Self-Rescuer, Safe Use and Care of Permissable Flame Safety Lamps, Dust Sampler, Noise Generation and Control, MSA Calorimetric CO Detector, MSA Nitrogen Dioxide Detector, MSA Hydrogen Sulfide Detector, Fyrite O_2 Indicator, Monoxor CO Indicator, MSA Universal Testing Kit, MSA Methane Spotter, Riken Methane Detector, M-402 Methanometer, G-70 Methanometer, Trailing Cable Splicer, Electrical certification. Certification is taking a position of greater importance in both United Mine Workers operations and non-union mines.

CURRENT FACULTY, STUDENTS, GRADUATES

Currently there are five full-time people on the faculty of the Mining Technology Department. At least six persons from other departments contribute to the curriculum as well. Extensive use is made of guest lecturers because of the number of mining professionals in Pikeville. Faculty expansion often times comes from the ranks of industry rather than from academia.

Most of the 131 (fall, 1977) students enter the program immediately after their high school graduation. Greater than 90 percent of them have come from the region and most will remain there after completion of the degree. Since 1975, sixty to seventy people have been graduating each year. Fewer than 10 percent of the students will seek additional schooling beyond this terminal degree.

An official reports excellent results with the Placement Office in locating graduates positions. Because of the strong industrial influence and orientation of the curriculum, employers are often times in close contact with the program director and in this way jobs are identified and placements are made. There is no shortage whatever of employment in mining technology with extremely competitive entry salaries for graduates.

PROGRAM PROJECTIONS

An associate in Mining Electricity degree will be offered soon. The specialized nature of the material which will be covered is such that the additional degree program is necessary.

In response to current surface ("strip") mining legislation an additional option in surface mining technology is being planned. The result will be a core curriculum in the first year which both the deep mining option and the surface mining option would take together and then a second year of specialization in one's selected area. The emphasis of such a program will be on compliance with reclamation regulations. One problem which is anticipated is that there will be difficulty in securing internship placements because surface mining is common to the western part of the state rather than for eastern section in which Pikeville is located.

ADDITIONAL INFORMATION

The Coal Industry Technical Assistance Center (CITAC) is a new service which is offered through this department to the small, private (i.e., non-Union) coal mine owner/operator. CITAC is essentially a free consultation service which provides information and instruction in mining regulation compliance; conducts seminars in up-to-date extraction techniques; and makes available the mining library on campus.

COURSE DESCRIPTION

MT 100 Evolution of Health and Safety Regulations - The evolution of coal mine health and safety. (1 s.h.)

MT 101 & 102 Techniques of Safe Mine Supervision - Development of skills in speaking, listening and writing. Use and understanding of The Bureau of Mines Dictionary of Mining, safety films, wage agreements, forms and reports required by government agencies. (3 s.h. each)

MT 103 & 104 Coal Science Fundamentals - Concepts of motion, matter, heat, electricity, magnetism, light, atoms, molecules, e.g., explosives, earth components, erosion, sedimentation, ground water as significant in the extraction of coal. (3 s.h. each)

MT 105 & 106 Mathematics for Mining Technology - General mathematical concepts in the solution of specific mining problems as selected from Bureau of Mines and various state's departments safety instructional materials. (3 s.h. each)

MT 110 & 111 Mine Operations and the Law - Specific phases of mining coal and how these relate to the Federal Mine Health and Safety Act of 1969 and various state laws. (3 s.h. each)

MT 112 Safety and First Aid - Principles of accident prevention and treatment of injuries. Taught by authorized Bureau personnel. (3 s.h.)

MT 113 Mine Rescue - Procedures and equipment utilized in mine rescue operations. (3 s.h.)

MT 114 Mine Maps - Development and reading of mine section maps. (2 s.h.)

MT 220 Coal Analysis - Approved methods of analysis of coal related to Bureau safety and requirements. (2 s.h.)

MT 212 Mine Operations and the Law - Opening, development and operation of a mine in accordance with mandated safety regulations. (6 s.h.)

MT 208 Preparation Plant Technology - Operation of a coal cleaning and preparation plant. (2 s.h.)

MT 206 Mine Ventilation - Installation and operation of mine ventilation equipment. (2 s.h.)

MT 203 Analysis of Mine Structures and Roof Control - Roof control in accordance with mandated standards. (2 s.h.)

MT 214 Mine Electricity - Assembly and operation of mine electrical circuits and equipment. (2 s.h.)

MT 222 Mine Blasting and Explosives - Care and use of explosives. (2 s.h.)

MT 201 Mine Safety Management - Mine safety management, cost and production factors related to safety. (3 s.h.)

MT 200 Mine Section Layout - Use of level, transit, plane table and other equipment applicable to development of a mine section layout. (3 s.h.)

MT 210 Mine Equipment Technology - State operation of major items of coal mining equipment. (4 s.h.)

INSTITUTION: POLYTECHNIC INSTITUTE OF NEW YORK

PROGRAM: Energy Engineering and Policy

DEPARTMENT: Interdepartmental

DEGREE: Certificate in Energy Engineering and Policy
Master of Science with Certificate in Energy Engineering and Policy

CONTACT: Dr. Edward S. Cassedy
Professor of Electrophysics
Department of Electrical Engineering/Electrophysics
Polytechnic Institute of New York
333 Jay Street
Brooklyn, New York 11201
(201) 643-8855

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

This program in energy engineering and policy began in 1973 as an interdepartmental effort to provide curricular and research activities in the field of energy studies.

The program is administered by an Energy Standing Committee composed of members of the participating departments, which include aerospace engineering and applied mechanics, chemical engineering, civil engineering, electrical engineering and electrophysics, management, mechanical engineering, metallurgy, nuclear engineering, operations research and systems analysis, physics, and transportation planning and engineering. The certificate can be awarded alone or with an M.S. degree from any of the participating departments.

PROGRAM REQUIREMENTS

Students must enter the energy program through one of the participating departments. This may be in a regular Master's degree program or in just the energy program. In either case, the student must meet the admissions requirements of the department's graduate program. Generally, the requirements include a bachelor's degree from an acceptable institution in the discipline in which the student wishes to continue his studies.

Requirements for the certificate alone include the completion of two required courses: energy policy issues and energy resource distribution and conversion technology, and six units (two courses) from one of twelve categories of energy electives. The twelve categories include:

1. Energy Conversion
2. Energy Transfer Processes
3. Environmental Impact of Energy Systems
4. Fluid Energy Systems
5. Management and Economics of Energy Systems
6. Materials
7. Nuclear Energy
8. Plasma and Controlled Fusion
9. Power Plant Construction and Engineering
10. Safety, Reliability, and Control of Energy Systems
11. Thermodynamics, Combustion, and Chemical Processes
12. Transportation

For the M.S. degree with certificate, a student must satisfy the minimum requirements of the M.S. program in his department along with the two required energy courses listed above and four energy electives, of which at least two must be from a single category. In many cases, departmentally required courses include those which may be used as energy electives. All elective course choices must have the approval of the departmental advisor.

CURRENT FACULTY, STUDENTS, GRADUATES

Program faculty is comprised of twelve part-time members who spend approximately one-third of their time teaching in the program, and fifteen part-time research faculty. Research funding is available from the U.S. Department of Energy and the New York State Energy Office.

The program has a current enrollment of six full-time and fifty part-time students. About fifty percent of these students are foreign. No specific program recruiting is done; students learn of the program through faculty, alumni, and other students. Some of the students receive some form of financial aid such as research or teaching fellowships. Several employed students have their tuition reimbursed by their employers. Quite a few of the foreign students receive assistance from their home governments.

The program averages approximately thirty graduates per year, with the number of graduates increasing slightly each year. Since most of the students already work for governmental agencies, industry, or engineering consulting firms, placement is not a problem.

PROGRAM PROJECTIONS

Officials hope to expand the program to place more emphasis on electric power subjects. Also under consideration is the possibility of establishing an undergraduate curriculum along similar lines as the graduate program. No estimate is available of when these changes might occur.

COURSE DESCRIPTION

ES 927 Energy Policy Issues - Review of broad policy problems connected with energy shortages. Aims" to reveiw essence of issues in roder to comprehend total energy policy framework and analytical tools to evaluate changing work, domestic conditions, and impact of alternative policy actions; to achieve a balanced appreciation of public controversies in energy policies, such as environmental impact. (3 s.h.)

ES 928 Energy Resource Distribution and Conversion Technology - Summary of present energy resources and global energy requirements. Attention to principles behind practical devices and to limitations imposed by fundamental laws of physics. (3 s.h.)

Graduate courses (selected):

AE 604 Noise and Acoustics II - Mechanism of noise generation by helicopters, fan engines, jets. Noise characteristics of automobiles, trucks, construction equipment. (3 s.h.)

CH 742 Design of Solid Waste Processing Systems - An evaluation of advanced solid waste processing technology with particular emphasis on processes still under development. Other modern techniques. (3 s.h.)

CH 756 Air Pollution Analysis - Principles of the reaction or physical measurement used for variety of analytical equipment employed in air pollution studies. (3 s.h.)

CH 757 Air Pollution Effects - Effects of armospheric pollution on various forms of life, including both direct and secondary effects. (3 s.h.)

CH 760 Energy - Resources, Conversion Technology, Distribution, Utilization - Comprehensive study of the energy problem in terms of available and potential resources of primary energy, conversion technology, distribution, and utilization, with emphasis on both economic and technical factors, also present and possible future environmental impact. (3 s.h.)

CE 741 Analysis of Water Quality Systems - Fundamental study of chemistry, biochemistry, microbiology, and application of these principles to water and wastewater treatment. (3 s.h.)

CE 747 Analysis of Stream and Estuary Pollution - Analysis of dispersal and decay of contaminants introduced into lakes, streams, estuaries, oceans. Effects of pollutant on chemical quality and ecology of receiving waters. (3 s.h.)

CE 753 Dispersion of Pollutants - Introduction to theory of diffusion of pollutants and methods for estimation of dispersion in atmosphere. (3 s.h.)

CE 770 Solid Waste Management - Engineering aspects of solid waste collection, transport and disposal, including incineration, sanitary landfill, composting, recovery and reutilization, economic evaluation of factors affecting selection of disposal methods. (3 s.h.)

ME 761 Energy Conversion - Energy resource, modes of energy conversion, and principles of energy conversion technology applied to electrical power generation, transportation systems, environmental control, and cryogenic systems. Interaction of energy conversion technology and environment. (3 s.h.)

ME 762 Topics in Energy Conversion - Analysis and evaluation of new alternative energy resources and energy conversion systems. Other selected topics. (3 s.h.)

ME 765 Environmental Control in Confined Spaces - Atmospheric control in enclosures. Heat load requirements, toxicity control, waste disposal, regeneration. Effect of chemical composition in artificial atmospheres on human performance. (3 s.h.)

NU 607 Reactor Licensing, Safety, the Environment - Governmental authority and responsibility, reactor licensing; nuclear power plant safety; dispersion of effluents from nuclear facilities; radiation doses from nuclear power plants; reactor siting; reactor accidents; accident risk analysis; environmental radiation doses; other environmental effects of nuclear power. (3 s.h.)

TR 854 Environmental Aspects of Planning - Current methods for assessing impacts of major facilities on environment, including natural, physical, economic, sociological, political implications. (3 s.h.)

INSTITUTION: PRINCETON UNIVERSITY

PROGRAM: Energy Conversion and Resources

DEPARTMENT: School of Engineering/Applied Science

DEGREE: Not degree granting, a Topical Program in Engineering

CONTACT: Dr. Michael J. Antal, Jr.
Department of Aerospace and Mechanical Sciences
School of Engineering and Applied Science
Princeton University
Princeton, New Jersey 08540
(609) 452-5125

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The topical program in Energy Conversion and Resources first initiated in 1973-74, offers engineering students an opportunity to supplement their departmental concentrations with intensive study in this area. In consultation with faculty advisors, students can design individualized curricula that emphasize energy conversion, energy resources, the environmental impact of energy technologies, or all three.

Formal association with the program is not necessary to take advantage of its offerings. Although based in the School of Engineering/Applied Science, the program encourages interactions with other departments and programs. If students decide to intensively study in the program, necessary background can be developed for either graduate study or a career in this area. Graduates find jobs in such areas as nuclear power, combustion engineering, coal gasification, cooling tower design, or fusion technology, among others.

Junior and senior independent research topics on energy topics may be prepared at the Center for Environmental Studies or in departmental research laboratories. Undergraduates often work on research projects with graduate students and faculty members. Projects may involve experimental work, computer studies, theoretical investigations, or a combination of all three.

PROGRAM REQUIREMENTS

Princeton University students are allowed to enter a topical program at any point in their undergraudate careers. The program is flexible enough to enable a student to simply gain a perspective on how energy issues interface with the major area of his or her academic concentration if the student chooses a lesser involvement with the program.

Those formally associated with this topical program have two advisors: one from their major department and the other selected from the Program Committee members. Two introductory courses (Engineering 101, Introduction to Technological Challenges, and Engineering 213, Energy and Environment: A Quantitative Approach) serve to introduce energy-subject matter broadly to students. Upperclass courses present opportunities for in-depth study in energy-related disciplines as each department in the School of Engineering/Applied Sciences offers advanced courses in one or more aspects of energy conversion. Students wishing to explore the non-technological aspects of energy provisions can take complementary courses in the natural sciences, humanities, and the social sciences.

In order to earn the Bachelor of Science in Engineering degree in the School of Engineering and Applied Sciences, students must complete at least 35 courses in their four years of study at Princeton. Independent work in lieu of a formal course, is encouraged for juniors and seniors. It is expected that undergraduate engineering students complete at least seven supporting technical courses in mathematics, science, and engineering, and a minimum of seven courses in the humanities and social sciences. Engineering undergraduates register in one of the four departments in the School and may elect to participate in such programs as Energy Conversion and Resources.

Fifty percent of the Princeton University undergraduates receive University scholarships or loans which are determined by need.

CURRENT FACULTY, STUDENTS, GRADUATES

The Energy Conversion and Resources Program Committee is made up of twelve faculty members form various departments in the School of Engineering and Applied Science. The program also has a research staff and guest lecturers. About one-third of each faculty member's time is devoted to sponsored research activites. Every faculty member conducts research in such topics as cooling tower designs, fusion reactor technology, geothermal power, solar energy conversion, new methods of producing hydorgen, basic combustion studies, and energy conservation in suburban housing. The U.S. Environmental Protection Agency has sponsored research on the conversion of organic wastes to fuels. The U.S. Department of Energy has sponsored combustion research and the National Science Foundation has sponsored energy conservation research. Between one to three million dollars in sponsored research money has gone into energy conversion and resources research each year for the past several years.

No current enrollment or numbers of annual graduates are available for this program because of its topical nature. Students can participate in the program's offerings loosely or intensely depending on their interest.

Virtually all graduates with training in Energy Conversion and Resources find jobs in their field of interest (which is very broad). About one-half each find jobs in either private industrial or research firms or in government. Approximately one to two students each year continue on for advanced degrees. Previous graduates have entered related graduate programs offered by the Massachusetts Institute of Technology, University of California at Berkeley, Stanford Research Institute, Purdue and Cal Tech.

PROGRAM PROJECTIONS

Program officials project a reduced program because of a shift in student interests toward the traditional engineering disciplines. Graduate students may be attracted to a program of this nature if the program was structured in a way which did not require completion of a traditional engineering degree. Present staffing will remain at a steady state for the foreseeable future.

COURSE DESCRIPTION

ENG 101 Introduction Technological Challenges - An examination, in-depth of three areas of impact between technology and society.

ENG 213 Energy and Environment: A Quantitative Approach - This course applies the ideas of elementary physics to issues of energy resource and energy utilization, emphasizing an environmental perspective, which is to say a perspective that puts the activities of man into the context of a natural setting with certain intrinsic constraints.

ENG 303 Environmental Studies - Subjects of current interest in the field of environmental studies will be studied and discussed.

CHEM 333 Chemistry and the Environment - Analyzes current environmental issues, such as energy resources and utilization, air pollution, water pollution, and pesticide and heavy metal contamination, from a chemical perspective.

EE 319 Energy Conversion and Resources - Materials Science and Design Principles of electric power transmission. Fundamentals and new developments in ultra high voltage transmission technology will be considered from the viewpoint of materials science.

MAE 424 Combustion Processes & Products in Energy Conversion - This course analyzes the combustion processes, the emissions and the efficiencies of energy conversion devices such as furnaces, spark and compression ignition reciprocating and rotary

MAE 424 (Cont.) - engines with uniform and stratified charges, mobile and stationary gas turbines and external combustion engines.

MAE 221 Thermodynamics - This course is a study of heat and work in their interactions in physical systems. The first and second law of thermodynamics and the concepts of energy transformation, entropy, availability and irreversibility will be developed, primarily from a macroscopic viewpoint.

CH E 341 Mass, Momentum, and Energy Transport - An engineer is interested in transport in flowing systems, and the fact that the material of interest, usually a gas or liquid, is in a state of bulk motion can have a profound effect on the transport properties of the system.

ENG 216 Chamical Methods for Environmental Control - This course is divided into three parts: a broad introduction to process engineering; the characteristics, design and use of catalytic chemical reactors for the conversion of pollutants to innocuous products and for the improved performance of separation processes; and the occurrence, production, and control of radioactive contamination of the environment.

GEOL 275 Engineering and Environmental Geology - An introduction to geology and the modification of the geologic environment through engineering construction and the exploitation of natural materials.

GEOL 314 Environmental Studies: The Physical Setting - Atmosphere, weather, climate, soil, water, and mineral deposits are discussed as factors in man's environment.

INSTITUTION: PURDUE UNIVERSITY

PROGRAM: Nuclear Engineering

DEPARTMENT: School of Nuclear Engineering

DEGREE: Bachelor of Science in Nuclear Engineering (B.S.N.E.)
Master of Science (M.S.)
Doctor of Philosophy (Ph.D)

CONTACT: Dr. P. S. Lykoudis, Head
Nuclear Engineering
Engineering Building, Room 250
Purdue University
West Lafayette, Indiana 47907
(317) 749-2676

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The School of Nuclear Engineering is one of nine engineering schools at Purdue. The undergraduate program began in 1970 with the first B.S.N.E. degres being granted in 1975. The graduate program started in 1960.

A five-year cooperative education program is offered that enables students to obtain engineering experience with selected industries, government installations, or consulting engineering firms while completing the requirements for a degree.

Graduate students in nuclear engineering usually select a primary area of study related to one of the following: reactor analysis, reactor safety and licensing, thermal-hydraulics, reactor dynamics and control, fuel system analysis and management, radiation transport and shielding, nuclear materials and radiation effects, nuclear system design, magneto-fluid-mechanics, or heat transfer in liquid metals.

PROGRAM REQUIREMENTS

A B.S.N.E. requires 126 semester hours:

Freshman Engineering	31 credit hours
Mathematics	11 credit hours
Physics	6 credit hours
General Education Electives	15 credit hours
Engineering Core	43 credit hours
Technical Electives	20 credit hours

The Department of Freshman Engineering administers the program of study for all new engineering freshmen and transfer students while they complete the basic core of courses common to the various professional engineering schools.

In the School of Nuclear Engineering, the M.S. and Ph.D. program of each student is planned on an individual basis. Principal requirements for the M.S. degree are satisfactory completion of a graduate course program and a thesis carried out under the supervision of a member of the faculty. Although there are no specific number of hours required, about 24 hours of course work are normally needed to accomplish a student's objectives. A non-thesis option is also available.

The principal requirements for the Ph.D. degree are a program of courses and the submission of a thesis based on an original investigation. Although no minimum number of course hours are specified, about 48 hours of total graduate school course work are normally needed to accomplish a student's objectives.

CURRENT FACULTY, STUDENTS, GRADUATES

Nuclear research projects have been funded by the National Science Foundation, Electric Power Research Institute, Argonne National Laboratory, the Nuclear Regulatory Commission and the Department of Energy.

Distinguished scholars are invited to the campus for yearly nuclear engineering seminars.

Ninety undergraduates are full-time students. Master and Ph.D. students number 45. Fifteen graduate degrees are awarded a year. There are ten full-time faculty members.

PROGRAM PROJECTIONS

The long-range goals and objectives are to expand the program with more concern for the quality of students than a large increase in the numbers of students.

ADDITIONAL INFORMATION

Facilities available for a wide variety of programs include a 10kw swimming pool reactor and an associated nuclear radiation transport research facility (including a neutron spectrometer), a natural uranium-graphite moderated subcritical assembly, fast breeder blanket facility (became operational in 1978), a fully equipped radiation instrument laboratory, a liquid-metal high-temperature heat transfer laboratory, a magneto-fluid-mechanics laboratory, a nuclear materials laboratory, a nuclear reactor safety laboratory and a large variety of auxiliary equipment.

COURSE DESCRIPTION (a partial listing)

Undergraduate (lower division):

200 Introduction to Nuclear Engineering I - A course designed to acquaint students with the field of Nuclear Engineering. Concepts of potential, nuclear models, fission, fusion, radioactivity, and neutron physics are introduced. (3 s.h.)

201 Introduction to Nuclear Engineering II - Continuation of NUCL 200. Transport processes, material problems, heat removal, reactor design principles, fuel cycles, economics and the interaction of nuclear power and society are discussed. (3 s.h.)

205 Nuclear Engineering Undergraduate Laboratory I - A laboratory course designed for the study of the properties of radiation, radioactive material and radiation detectors. The hazards of radiation and safe handling techniques are emphasized. (2 s.h.)

Undergraduate (upper division):

302 Reactor Engineering - Special problems in heat transfer and materials in reactor design. Principles of radiation shielding. Nuclear and economic aspects of the nuclear fuel cycle. (3 s.h.)

305 Nuclear Engineering Undergraduate Laboratory II - Continuation of NUCL 205. Experiments with scintillation detectors, multichannel analyzers, neutron detectors, and the subcritical pile will be performed. Measurements will be made to demonstrate neutron activation analysis techniques, neutron slowing down, neutron flux distributions, and the effects of control rods on neutron fluxes. Experiments or demonstrations in the areas of radiation damage to materials and reactor thermal-hydraulics will be included. (2 s.h.)

310 Introduction to Neutron Transport - Development of diffusion theory for neutrons. Neutron interactions and development of one-group neutron diffusion theory with point, plane, and fission sources. Application to one and two-region reactors. Introduction to buckling, multiplication constants, critical size, neutron slowing down, and resonance capture. Applications using two-group theory. (3 s.h.)

400 Atomic and Nuclear Structure and Interactions - Review of atomic structure and introduction of nuclear structure models. Review of quantum mechanics with application to nuclear phenomena. Discussion of radioactive decay and the interaction of nuclear radiation and reaction products with matter. Energetics and cross sections for nuclear reactions. Applications of cross section information to nuclear engineering problems. (3 s.h.)

450 Design in Nuclear Engineering - Application of the design process to the design of various engineering components and systems. Mathematical modeling in design. Neutronic, thermal, fluid, material, safety, and strength problems are considered. (3 s.h.)

Undergraduate/Graduate:

501 Nuclear Engineering Principles - A first course for graduate students desiring a nuclear engineering sequence. Nuclear structure; nuclear radiations; neutron behavior while slowing down and diffusing; fast and thermal reactor theory; and control. (3 s.h.)

502 Nuclear Engineering Systems - Engineering aspects of nuclear power. Materials of construction; fuel and fuel cycles; heat removal; radiation sheilding; economics; and nuclear power systems. Some background in heat transfer is recommended. (3 s.h.)

504 Nuclear Engineering Experiments - A laboratory course which when coupled with NUCL 500 produces a sequence that contains both the theoretical and engineering aspects of nuclear engineering. Topics include radiation detection and analysis; neutronics; radio-chemical separations; and nuclear reactor experiments. (3 s.h.)

510 Nuclear Reactor Theory I - Basic multigroup theory, neutron slowing down, classical calculation of multiplication constants, two-group theory, introduction to transport theory, two-dimensional flux distributions, reactivity balance. (3 s.h.)

520 Radiation Effects and Reactor Materials - Introduction to radiation effects in solids and a survey of nuclear reactor materials. Radiation interaction mechanisms and effects on properties. Reactor material characteristics, selection criteria, testing, and economic considerations. (3 s.h.)

544 Nuclear Fuel Systems - Nuclear plant economics with emphasis on the effect of the nuclear fuel cycle on reactor design. Preparation and recovery of reactor fuels, core loading management, fuel design, plutonium and thorium systems. (3 s.h.)

550 Nuclear Power Systems - A guide to the specialized literature and informational services of nuclear engineering. Practice in literature research methods. (1 s.h.)

Graduate:

601 Nuclear Reactor Safety and Licensing - A broad treatment of reactor design parameters which are relevant to reactor safety and licensing, including environmental and societal factors. Kinetics and control requirements, accident analysis, safety design analysis, engineered safeguards, and siting. Consideration licensing requirements and interplay with technological, economic, environmental, aesthetic, and social factors. (3 s.h.)

602 Nuclear Power Plant Design Analysis - Review of economic, engineering, and neutronic parameters which affect the optimization of a nuclear power plant, optimization procedures and design criteria. Preparation of a reference conceptual design and evaluation of a proposed power reactor plant. (3 s.h.)

620 Materials Phenomena in Nuclear Reactor Systems - Materials phenomena unique to nuclear reactor environments are examined quantitatively. The relation between these phenomena and the structure and properties of engineering materials is discussed. Coupled phenomena are considered in relation to materials modeling codes. (3 s.h.)

650 Thermal-Hydraulics for Nuclear Reactor Safety - Review of safety philosophy, levels, and goals of safety. Approaches used for nuclear reactor safety for protection of the public health. Design basis accidents. Engineered safeguards and inherent safety features. Fundamentals of safety related thermal-hydraulic phenomena and their integration into a methodology for containment assessment. (3 s.h.)

INSTITUTION: RENSSELAER POLYTECHNIC INSTITUTE

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Engineering

DEGREE: Bachelor of Science (B.S.); Master of Science (M.S.); Master of Engineering (M.E.); Doctor of Philosophy in Nuclear Engineering (Ph.D.)

CONTACT: Dr. J.C. Corelli
Nuclear Engineering Department
Rensselaer Polytechnic Institute
Troy, New York 12181
(518) 270-6403

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Initiated in 1960, the Nuclear Engineering Department offers programs of instruction for both undergraduates and graduate students. The undergraduate program's principal aim is on the energy product aspects of nuclear reactor technology. Areas of concentration are available in: Reactor Physics; Reactor Engineering; Applied Physics; and Health Physics. The Health Physics Concentration is intended for Professional Program students who wish to develop expertise in tha radiation safety aspects of nuclear power plant operations and the associated nuclear fuel cycle. Undergraduates can select eight electives from this concentration which are directly related to radiation control. The undergraduate program is intended to prepare students for either industrial employment or graduate study. The program is monitored by an industrial advisory council composed of representatives of various companies in the energy field.

The graduate program in Nuclear Engineering is mainly related to both fundamental research and industrial applications, and is mostly concerned with electric power production from nuclear energy. Other areas of emphasis are medical and other uses of radiation and radioactive materials, reactor thermalhydraulics, reliability and safety, fusion materials technology, radiation wastes, and applied physics. In the graduate program, students select courses covering specialized material in any program area and work with a member of the faculty or research staff who has corresponding interests. The student's research topic is selected in consultation with the faculty or research staff member who works in the student's area of interest. The individual's needs and career objectives are met through core courses, course work in a particular area of concentration, and associated research programs.

The Nuclear Engineering Department contains a large number of various facilities: a 100-million electron-volt linear accelerator; extensive mass and radiation spectrometry facilities; a large critical facility for operational training and safety studies; two-phase flow loops; probes to determine radiation damage in biological materials, fusion reactor materials, and semiconductors; computer terminals linked to large remote computers; an in-house developed interactive graphics computer system; a high-current, low voltage electron accelerator for low voltage electron accelator for low-energy radiation damage effects; and a Van de Graaf accelerator subcritical reactor assembly.

PROGRAM REQUIREMENTS

In order to enter as candidates for the Bachelor of Science degree, applicants are evaluated by Rensselaer's Committee on Admissions. This Committee pays particular attention in its evaluation to:
(1) Academic performance throughout secondary school;
(2) results of the College Entrance Examination Board Scholastic Aptitude Tests and Achievement Tests, in English composition, physics or chemistry and Mathematics I or II;
(3) the recommendation from the applicant's school; and
(4) character and extracurricular achievements.
Prospective applicants to the graduate program must have a Bachelor of Science degree in Nuclear Engineering or any other engineering branch. Also accepted are students possessing a Bachelor of Science degree in physics or mathematics.

Undergraduates may follow either a program leading to the Bachelor of Science degree or be admitted to the professional program leading to the Master of Engineering degree as well as the Bachelor of Science degree. For example, a student can elect a concentration in radiological health (5 yr. program) after earning the B.S. degree and supplement the program with electives to develop a minor in health physics. Two electives can be taken as a senior in radiation health.

The engineering baccalaureate program requires completion of a total of 133 semester credtis. Twenty-four credit hours of humanities and social sciences electives are required. One course in computing and a sequence of other mathematics courses, at least through advanced calculus, are also required to earn the bachelor's degree. Nuclear Engineering courses required include: 30.282 Introductory Nucleonics; 38.471 Radiological Engineering; 38.401 Elements of Reactor Engineering; 38.412 Nuclear Reactor Analysis I; and 38.402 Nuclear Energy Conversion. Three additional Nuclear Engineering courses are generally elected by many B.S. students.

The first year of the Master of Engineering professional program requires course work that is more heavily oriented toward advanced Nuclear Engineering courses, Mathematics courses, and laboratory courses. Seniors with advanced placement may supplement their course work with electives in an area of concentration. The second year normally consists of eighteen course credits and six credits of 38.698 Master's Project of 38.699 Master's Master's Thesis. One credit of 38.910 Engineering Seminar is required. A minimum total of thirty credits which include ten credits of design-oriented courses and ten hours in advanced mathematics and engineering science are required. Only students with B.S. degrees from institutions accredited by the Engineers' Council for Professional Development (ECPD) are admitted to the M.Eng. program. The B.S. program is also accredited by the ECPD.

The Master of Science degree program is arranged by consultation with a faculty advisor and the formal minimum requirement is 24 credits of course work, one credit hour of 38.910 (Seminar), and 6 credits of the master's thesis. M.S. students may take 5 to 6 courses from the Health Phsycis Concentration and prepare 6 credits of research in a radiation effects or radiological health project to develop a program of study in radiation protection.

A thesis advisor assists students in preparing advanced study and research in the doctoral programs. Ususally 45 to 60 course credits beyond the B.S. degree are required in addition to the residence and thesis requirements. Each Ph.D. candidate is required to submit a draft of a technical paper to be published in a referred journal.

Financial aid available includes two fellowships from the Department of Energy (formerly ERDA), four industry fellowships, four teaching assistantships, and 20 research assistantships. Program officials would like to develop a stronger radiation protection program but currently lack a U.S. Environmental Protection Agency fellowship to enable it to be started.

CURRENT FACULTY, STUDENTS, GRADUATES

Eleven full-time teaching faculty present the Nuclear Engineering Department's curriculum to students. All full-time faculty members are involved in conducting research. They are partially (50%) supported by research funding. Current areas of advanced study and research which impact radiation protection topics include: radiation effects in materials; reactor safety; radioactive waste management; and environmental measurement. The department's faculty are also conducting a project on the effects of ionizing and non-ionizing radiation on biological systems.

A total of 115 full-time students are enrolled in the baccalaureate program (7 females). Six undergraduates have elected health physics courses as elective concentrations, and it is estimated that three to four students have elected the environmental surveillance concentration of courses. At the M.S. level, there is currently a total of 62 students enrolled. Of the total, there are 50 full-time (3 female) and 12 part-time students enrolled. Seventeen full-time students are enrolled in the doctoral program

Department officials estimate that an annual three-year average of 30 B.S. degrees, 18 M.E. and M.S., and 5 Ph.D.s are granted. Enrollment appears to have increased significantly over the past few years.

Forty percent of the M.S. graduates contine on to earn doctorates. Many stay on at the Rensselaer Polytechnic Institute, but others (in the past) have contined on to programs offered by such schools as the Massachusetts Institute of Technology, the University of Virginia, the University of Michigan, and Cornell University.

Virtually all graduates obtain employment directly in their field, and a predominate number (40%) obtain governmental positions in agencies such as the U.S. Nuclear Regulatory Commission in preparing environmental impact assessments of nuclear power plants. Others find radiological health positions at nuclear power facilities and national laboratories. Some graduates secure jobs in nuclear power plant operations, and others find positions in nuclear medicine or in radiology departments in hospitals.

PROGRAM PROJECTIONS

Department officials project a greater need for graduates trained in radioactive waste management in future years. One new faculty member is to be recruited to teach nuclear waste management. By 1978, the department hopes to recruit a Ph.D. with training in radiation waste management, as this is an area in which the department is currently lacking in expertise. An additional two graduate fellowships are needed to develop a strong area of concentration in the Nuclear Engineering Department in radiation waste management. Enrollment in both the undergraduate and graduate programs is expected to continue increasing.

COURSE DESCRIPTION

(the following is a partial listing of courses)

38.406 Nuclear Fuel Management - Sources of nuclear fuel. Mining, milling and purification. Principles of isotope enrichment; specific methods with emphasis on gaseous diffusion. Other important topics. (4 s.h.)

38.628 Interaction of Radiation with Biomaterials - Ionizing and nonionizing energy transfer processes to biomaterial such as live mammalian and bacterial cells. (3 s.h.)

38.629 Health Physics and Medical Aspects of Radiation - Use of radiation in nuclear medicine, effects of ionizing and non-ionizing radiation in biological systems. Radiation and environment interactions. (3 s.h.)

38.632 Safety Controls for Nuclear Operations - Emphasis is on nuclear power plants but other power systems are included. Analysis and review of quality assurance of systems and quality control, atmospheric diffusion of plant effluents, and others. (3 s.h.)

38.635 Radiation Shielding - A course concerned with the design and analysis of radiation shielding. The emphasis is on shielding design and analysis in the nuclear power industry. (3 s.h.)

Chemistry:

72.471 Nuclear Chemistry - Properties and models of atomic nuclei, radioactive decay processes, laws of growth and decay of radionuclides, properties of nuclear radiation, interactions of nuclear radiation with matter, nuclear instrumentation, radiation protection, nuclear reactions, methods of radiochemistry. (3 s.h.)

72.472 Radiochemistry - Radioactivity measurements; determination of half-life and radiation characteristics of radionuclides; study of genetic relationships, radiochemical separation methods; autoradiography; characteristics of radiation detectors including gaseous, solid and liquid scintillation and solid state types; nuclear spectrometry by both single and multichannel pulse-height analysis; isotope dilution and activation analysis. (3 s.h.)

INSTITUTION: SOUTHERN TECHNICAL INSTITUTE

PROGRAM: Nuclear Safety

DEPARTMENT: Electrical Engineering Technology

DEGREE: Associate of Science

CONTACT: Professor Julian R. Lee
Southern Technical Institute
534 Clay Street
Marietta, Georgia 30060
(404) 424-7371

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Although the two-year option, which began in the fall of 1974, may culminate with an A.S. degree, most of its students continue in the four-year Electrical Engineering Technology program which leads to a Bachelor of Engineering Technology degree. Approximately half of those earning this degree are satisfying the requirements for two separate options.

Nuclear Safety requires that the student be proficient in electronics, in radiation physics, in principles of health physics, and in applied health physics. Graduates will be qualified for technological positions in development, testing, monitoring, research, sales, and maintenance in the nuclear field. Such positions as radiation-instrument technologist, and health-physics monitor can be filled by the graduates of this program.

Southern Tech is a division of nearby Georgia Institute of Technology so it has access to the nuclear reactor and nuclear instrumentation there. Southern Tech has its own reactor simulator, air quality monitoring system (sensitive to ambient radiation), thermoluminescent dosimeter reader, and numerous radiation counters. It is important to note that although students are learning techniques of operating a nuclear reactor, being a reactor operator is an occupation which requires licensing for the specific nuclear reactor on which one will be employed to operate. This requires an examination as well as a satisfactory demonstration of expertise.

PROGRAM REQUIREMENTS

Students wishing to be admitted to Southern Tech should complete three credits of English, two of algebra, one of plane geometry, and two of science during high school. Applicants must be high school graduates or the equivalent (GED). All freshman applicants must submit Scholastic Aptitude Test scores. Students who have deficiencies in one or more of the admission requirements may be admitted to Special Studies subject which supplement the high school record.

Prior to enrolling in nuclear safety, three prescribed physics courses must be completed. The curriculum in this option is inflexible rather than being suggestive. First year students must enroll in nine quarter hours of English, eighteen hours of mathematics including a course in computer programming, fifteen hours of chemistry and physics, in addition to two hours of engineering drawing and six of circuit analysis. The second year plan is outlined in the Course Description; however, generally, it requires thirty-two hours of electronics, three hours of technical writing, five hours entitled Heat, Sound, Light and Modern Physics. Thirteen hours refer specifically to radiation: Introduction to Nuclear Radiation, Principles of Health Physics, and Applied Health Physics. Graduates of this option must satisfy the requirements of the examination on the Constitution and Government of the United States and Georgia as required by state law.

CURRENT FACULTY, STUDENTS, GRADUATES

One faculty member coordinates, plans, and provides radiation/nuclear instruction for this option. When he is unable to be on campus to fulfill these responsibilities, a designated faculty member from physics substitutes for him. Additional instructional support comes from the other departments in which requirements of this program are offered.

Each of the ten students who are enrolled intends to pursue a B.E.E. degree, and upon graduation nearly half will be employed as engineers. Often times people who have enrolled in nuclear safety were in the military or have come from other institutions which do not have such an option.

The enrollment figure is down substantially from 1976's level of seventeen. This, it is felt, is in direct response to the negativism which has been generated by the controversy over the use of nuclear energy. Although a recruitment effort is going on, it is, for the large part, judged unsuccessful.

Follow-up questionnaires were sent to former students, but there was only minimal response to it. The Placement Office estimates that there exist ten positions in the field of radiation for each person who completes this option. Nearly all of those who do accept related positions are working for private firms rather than the government because salaries are much higher in the private sector.

PROGRAM PROJECTIONS

There is a need to add a course in the area of law as it pertains to the use of nuclear energy, one in reactor technology (repair and operations), and one in radiobiology. It is hoped that sufficient enrollment increases will occur to warrant acquiring additional faculty and facilities, and eventually to allow nuclear safety to attain department status and lead to a four-year degree, the Bachelor of Nuclear Engineering.

In addition to extending nuclear safety to a four-year program, officials would like to add one program in nuclear reactor operations in the Department of Mechanical Technology.

COURSE DESCRIPTION

EET 272 Introduction to Semiconductor and Electronic Devices - Physics and conduction properties of insulators, conductors, and semiconductors. Single stage circuits using graphical and analytical techniques. (6 q.h.)

EET 274 Circuit Analysis - Circuit theory and practice as applied to single-phase ac circuits. Response of RLC networks; impedance and admittance functions; complex notation, rms and average values; equivalent circuits. (6 q.h.)

EET 300 Semiconductor Circuits and Devices - Static and dynamic characteristics of semiconductor diodes, transistors, unijunctions, silicon controlled rectifiers, and other semiconductor devices. Transistor circuit analysis using methods of four-terminal network analysis with emphasis on h and t parameters. (6 q.h.)

EET 301 Computer Fundamentals - Digital computer systems; number systems, application of logic circuits to computer design; introduction to Boolean algebra. Logical design of digital computers. (4 q.h.)

EET 302 Circuit Analysis - Continued study of circuit theory and practice. Network theorems, elementary transients, resonant circuits, and coupled circuits. (4 q.h.)

EET 340 Pulse and Digital Circuits and Applications - Linear and nonlinear circuits used in generation and shaping of waveforms, including design and analysis of multivibrators, clippers, clampers, and logic circuits. Application to digital techniques such as computing telemetry and measurement systems. Primary emphasis on semiconductor circuits including integrated-circuit techniques. (6 q.h.)

ENGL 231 Technical Writing - Fundamentals of technical writing style, practice in preparing reports of types likely to be used by engineering technologists. (3 q.h.)

PHYS 203 Heat, Sound, Light and Modern Physics - Theories of heat, sound and light and their simpler applications. Includes thermometry, calorimetry, heat transfer, thermodynamics, reflection and refraction of light, mirrors, lenses, interference, diffraction, and polarization. Brief considerations of relativity, atomic structure, radioactivity, and nuclear energy. (5 q.h.)

PHYS 375 Introduction to Nuclear Radiation - Physical basis for understanding effects of ionizing radiation on matter. Developing of a philosophy of radiation for individuals and environment, and for radiation-protection programs. (5 q.h.)

PHYS 377 Principles of Health Physics - Introduction to health physics. Biophysical bases of radiation protection criteria. Philosophy and methodology of Nuclear Engineering Technology. Operation of a nuclear reactor using nuclear-reactor simulator. (4 q.h.)

PHYS 379 Applied Health Physics - Health physics in our society. Control of radiation in industry and medicine. Personnel monitoring, bioassay, air sampling and respiratory protection, radiation surveys of nuclear reactors, accelerators, radioisotope laboratories, and x-ray installations, emergency planning and control of emergency conditions, professional ethics and judgment, and government regulation of ionizing radiation. (4 q.h.)

INSTITUTION: TEXAS STATE TECHNICAL INSTITUTE

PROGRAM: Nuclear Systems Technology

DEPARTMENT: Nuclear Technology

DEGREE: Associate of Applied Science (A.A.S.) in
Nuclear Technology

CONTACT: Dr. Robert Brown
Chairman, Nuclear Technology
Texas State Technical Institute
Waco, Texas 76705
(817) 799-3611

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Nuclear systems technology was developed as a two-year program leading to the Associate of Applied Science degree in September of 1974. The program prepares students for occupations, as technicians, in the nuclear energy field. Graduates of this program are employed in a wide variety of technician level jobs. Historically, students have entered occupations such as: radiation chemistry technician; reactor operator; quality assurance technician; and, nuclear instrumentation technician. Most graduates enter the nuclear power industries. There are, however, opportunities available to these graduates in research, medicine, agriculture, and other areas where radiation and radioactive materials are utilized.

PROGRAM REQUIREMENTS

The nuclear technology program has two options available to students: quality assurance/quality control; and, radiation protection. The program involves a two-year commitment on the part of students. The Institute utilizes the quarter system, and therefore, six quarters are required for completion of the associate degree.

The first four quarters consist of common requirements for students electing either option. During this time, the student is required to successfully complete the following: four courses in measurement, electricity, blueprint reading, and instrumentation; two courses in communications; four courses in chemistry, physics, and mathematics; and, nine courses in nuclear technology. These requirements include classroom time as well as laboratory sessions, for approximately 25 hours per week.

The remaining two quarters consist of requirements which are confined to one of the two options. The student electing quality assurance/

quality control, is required to complete: one course in welding inspection and one course in electrical and instrumentation inspection; and, seven courses in nuclear technology which include NCL 301, 303, 305, 311, 312, 313, and 314.

The radiation protection option requires the following two quarters of course work: one course in chemistry and one in environmental health and safety; and, six courses in nuclear technology which include NCL 302, 307, 308, 309, 312 and 315.

The program is structured so that the student may work in nuclear industries during the summer between the two school years.

CURRENT FACULTY, STUDENTS, GRAUDATES

The current full-time faculty with responsibilities for the nuclear systems technology program, consists of two persons. Both of these faculty members are cost-centered.

At present, there are 35 total students in the program. Of the total, 34 are male and one is female. There is a comprehensive program of grants, loans, scholarships and student employment which is available to most students.

Approximately 12 to 15 students graduate from this program annually. Usually, two students from each class will choose to continue their studies through the baccalaureate level. Those choosing employment enter the private sector (90%) predominantly.

PROGRAM PROJECTIONS

The program faculty and staff are projecting an increase in student enrollment. Officials of the Institute are desirous of expanding the program to include 60 full-time students. Changing program emphasis will include stressing the vocational-technical aspects. Pursuant to these growth plans, it is anticipated, by the Institute, that one faculty member will be added within two years.

COURSE DESCRIPTION

NCL 100 Orientation for Nuclear Technicians - A survey course designed to acquaint the student with the job entry specifications and occupational opportunities in the field of Nuclear Technology. (1,0,1 q.h

NCL 102 Introduction to Nuclear Technology - An introduction to the principles and applications of nuclear energy. (2,2,3, q.h.)

NCL 104 Radiation Detection and Measurement - A course in the principle and methods used to detect and measure radiation with emphasis placed on ionization and scintillation detectors. (3,4,5 q.h.)

NCL 106 Radiation Physics - A study of atomic and nuclear structure, radioactivity, and interaction of radiation with matter. (3,3,4 q.h.)

NCL 202 Introduction to Nuclear Systems - A study of the major components of the reactor core, pressure vessel, shield, and primary cooling water systems. (3,3,4 q.h.)

NCL 206 Radiation Protection - An introductory course to familiarize the student with the field of radiation protection. (3,4,5 q.h.)

NCL 210 Power Plant Systems - A study of the "balance of plant", that part of the electrical generating plan common to both nuclear plants and fossil plants. (3,3,4 q.h.)

NCL 307 Reactor Physics - A study of the principles of nuclear reactor operation including neutron behavior, fission process, neutron balance, criticality, and actual operating procedures. (3,2,4 q.h.)

NCL 308 Radiation Protection - A second course in the field of protecting human beings from injury from radiation. (3,4,5 q.h.)

NCL 309 Radiological Emergencies - A study of the procedures to follow during a radiological accident. (3,3,4, q.h.)

NCL 312 Special Projects and Seminars - (3,8,5 q.h.)

NCL 315 Radioactive Waste Disposal and Management - How to monitor and dispose of radioactive materials being transported off-site. (3,3,4 q.h.)

NCL 320 Reactor Operating Procedures - The actual operation of reactors. (3,3,4, q.h.)

NCL 324 Statistical Quality Control - Basic statistical techniques. (3,3,4 q.h.)

NCL 402 Advanced Reactor Physics - Theory and principles of nuclear reactor operation. (3,3,4 q.h.)

NCL 408 Environmental Impact Reports - A study of the various aspects of environmental impact reports. (3,3,4 q.h.)

NCL 412 Reliability in Nuclear Facilities - A study of procedures for assessing, organizing, and operating a reliability function for nuclear facilities. (3,3,4 q.h.)

INSTITUTION: THE OHIO STATE UNIVERSITY

PROGRAM: Program for Energy Research, Education, and Public Service
DEPARTMENT: (university-wide program)
DEGREE:

CONTACT: Dr. Robert E. Bailey, Director
Program for Energy Research, Education, and Public Service
The Ohio State University
111 Oxley Hall
12th and Neil Avenues
Columbus, Ohio 43210
(614) 422-5485

PROGRAM DESCRIPTION:

Environmental educators are becoming increasingly aware of the critical role our energy resources play in our quality of life. Energy production, utilization, and conservation demand our social, technological, economic and educational attention. The Ohio State University, recognizing the capabilities of the institution in the field of energy problems and policies, established the Program for Energy Research, Education, and Public Service in 1976. The Program (PEREPS) coordinates the University's activities in the energy field, and depending on the needs of the faculty and students, assists in locating research support and identifying OSU colleagues with expertise in a given area. The Program's purposes are three-fold:

(1) To help the citizens of Ohio better manage their energy resources.
(2) To help the academic community enhance and share their professional skills as they relate to energy.
(3) To help students find the available resources needed to improve their ability to deal with energy-related issues.

The Ohio State University has a number of notable projects underway:

(1) More than thirty sponsored energy research projects with annual budgets totaling two million dollars;

(2) One million dollars in ERDA awards from March 1976-1977;

(3) Designation of the University as the site for the new National Regulatory Research Institute;

(4) Establishment of a coal professorship in the College of Engineering; and

(5) A symposium and roundtable entitled "Energy, the Environment, and Our Society," sponsored by the University's Battelle Endowment Program.

PEREPS contributed to the above mentioned University efforts and initiated programs of its own. Some of these projects, enumerated in the Program's annual report, include:

(1) A major survey of citizen attitudes in the State of Ohio on energy-related questions;

(2) Ten seed grants funded with institutional dollars to university faculty;

(3) Establishment of working groups in the areas of (a) energy impacts on the environment and (b) energy public policy;

(4) Development of several new graduate courses--in economics, on environmental implications of energy production and use, and on energy policy issues.

The research component of PEREPS constitutes a major thrust of its activities involving faculty members and graduate students on the OSU campus. A number of investigations related to coal and natural gas are currently underway--some of them funded by the Program. To expand this effort and to focus on this important research, the University is considering the formation of a Center for Coal and Gas Research. Among the primary studies of this proposed Center are investigations in the desulfurization of coal--the reduction of coal to small particle sizes--and the production of natural gas from Ohio sandstone, shale, and coal seam deposits, and from small-particle coal.

Research efforts concerning alternative sources of energy have literally built a "solar house" located at the Ohio Expositions Center in Columbus. The structure "is equipped with solar collectors, water storage tanks, and other items which comprise a solar energy recovery system." Ohio State also maintains a prototype solar pond which can be used to generate low temperature heat needed for crop drying, for heating of farm buildings, and for food processing. These ponds represent a stored source of summer solar input for winter use.

Conservation plays a major role in the energy program on the Columbus campus. In-depth studies of energy use and energy conservation modifications have been conducted for a number of university buildings. "A major thrust of the energy conservation program has been to enlist the cooperation of the faculty, staff and students and to generate a sense of energy consciousness in everyone." The University also has played a major role in the planning of an Energy Extension Service for the State of Ohio.

The designation of Ohio State as the National Regulatory Research Institute has intensified the University's national role in energy activities. The NRRI is committed to research, education, and service. The latter two functions "provide the means of disseminating the knowledge gained through research, as well as provide an opportunity for NRRI staff to communicate with others in the field and better understand the problems faced by those actually in regulatory agencies." The Institute, part of the National Association of Regulatory Utility Commissioners (NARUC) overall operation, serves "to establish a comprehensive, high quality, applied program of regulatory research, responsive to the research needs of the NARUC members."

The Program staff has also been heavily involved in extension work and projects on the Ohio State campus and beyond its borders. Numbered among these activities are: a solar conference, National Association of Home Builders Regional Conference, Ohio Cities Consortium energy conservation workshops, OSU Regional Campus/Community Energy Conference, and the Ohio River Basin Energy Project. The last entry represents a nine-state interdisciplinary technology assessment study funded by the Environmental Protection Agency.

The Energy Research, Education, and the Public Service Program at Ohio State University is committed to the support of basic research, education, and public involvement from many sectors. Personnel maintain that the EPA must fund such basic research--the Agency may be one of the last environmentally-oriented bastions of financial support left to the universities. Good social and economic research efforts are needed to show the long-range implications of EPA programs and policies. Students must have a background in problem-solving methodology; and their exposure to research is critical to achieve that end.

INSTITUTION: THE OHIO STATE UNIVERSITY

PROGRAM: Summer Energy Workshop for Teachers of Science, Mathematics, and Social Studies

DEPARTMENT: College of Education, College of Engineering

DEGREE: Graduate Credit (6 hours)

CONTACT: Mr. Robert Tait, Special Projects Officer
Office of the Dean
College of Engineering
Hitchcock Hall
Ohio State University
Columbus, Ohio 43210
(614) 422-4937

PROGRAM DESCRIPTION:

Outreach and pragmatic education mark the Ohio State University's Summer Energy Workshop for high school and upper elementary school teachers. Sponsored by the U.S. Energy Research and Development Administration (now the Department of Energy) and coordinated by the Colleges of Education and Engineering, the workshop is "geared to the needs of school teachers who are faced with teaching timely material about a topic which continues to be in the forefront of state, federal, and community concerns." Sessions concentrate on the technical, social, and economic ramifications of energy management. According to an OSU College of Engineering publication, "The aim is to teach teachers how to teach more about the topic of energy and to help create a generation of energy-conscious and energy-wise citizens for a future which may grow ever bleaker in terms of abundant supply." As Dr. Donald D. Glower, Dean of the College of Engineering states:

> The ultimate point, of course, is to reach the people who will be adults in the 1980's, inform them of needs, problems, and alternatives so that when the time comes, they are better equipped to make intelligent and informed decisions as voting citizens. High school teachers today have a key role in helping their students learn to be rational and not merely ill-informed people swayed by emotion or guided by intuition or guesswork.

Topics covered in this three-week learning experience include: energy use and alternatives; future sources of energy (breeder and fusion reactors and solar energy); interrelationships between energy, economics, and politics; toxicity of plutonium in relation to other hazardous chemicals in common industrial use; energy pricing and conservation; siting, licensing, and regulation of nuclear power plants; principles and operation of light water, boiling water, and pressurized water nuclear reactors and the high temperature gas cooled reactor and liquid metal fast breeder reactor; radiological environmental concerns; nuclear fuel cycles; containment and disposal of radioactive wastes; coal research; and the thermodynamics of power plants. Workshop participants sample Lake Erie water quality, monitor air for background radiation, tour a fisheries laboratory, visit a NASA wind generator, tour Ohio coal fields, fly over strip mine lands before and after reclamation, and visit stripping and reclamation operations.

For the participants (31 in 1977), who receive six hours of graduate credit, the Energy Workshop is invaluable and prompts exciting curriculum changes in schools across the state. The workshop reflects the University's awareness that our energy problems demand input from engineers, geographers, sociologists, economists, educators, and informed citizens.

INSTITUTION: THE PENNSYLVANIA STATE UNIVERSITY

PROGRAM: Minerals Processing

DEPARTMENT: Materials Sciences

DEGREE: Master of Science; Ph.D.

CONTACT: Dr. Leonard G. Austin
Section Chairman of Minerals Processing Section
Department of Materials Sciences
108 Mineral Industries Building
The Pennsylvania State University
University Park, Pennsylvania 16802
(814) 863-0373

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The Mineral Processing Program first initiated in 1945, has opportunities for students to become involved in solving environmental problems as process engineering involved large plants which treat millions of tons of material per year at low cost. The design and operation of these processing plants must allow for the disposal of large quantities of waste materials without damage to the environment. Many air and water pollution control methods use equipment and processes originally developed for minerals treatment or processing of minerals of metals and other materials. Students have an opportunity to emphasize pollution control through both course work and thesis research. The program also cooperates with the all university interdisciplinary program leading to the Master of Science in environmental pollution control or the Master of Environmental Pollution Control.

Excellent employment opportunities exist for mineral process engineers. Demand for personnel significantly exceeds the number of graduates in this field. Employment opportunities exist within the mining, metalurgical, cement, power, and heavy chemical industries as either minerals processing engineers or metallurgists. Graduates may be trained to run a coal cleaning plant associated with mines, for example, and graduates have gone to work with oil companies.

A minerals processing option is being developed within the Mining Engineering Program. The B.S. Minerals processing option within Mining Engineering is scheduled to begin in the fall term, 1978.

Graduate students have access to laboratory and pilot plant facilities within the department plus laboratory facilities located within the Materials Research Laboratory. The minerals constitution laboratory contains excellent analytical equipment and is considered one of the best in the nation. Mineral and particulate-material processing research are included in Energy and Environmental Problems Research conducted by the Department. Specific interests include: sulfur and ash removal from coal; sulfur removal from stack gases; mine and process water treatment; solid waste disposal, recycling, and utilization; and slagging characteristics of coal.

The program is currently undergoing a change in structure in administration. The Minerals Processing Option will in the future be offered by the Mining Engineering Department. Minerals Processing courses will also split from Metallurgy Program courses which are currently integrated. Minerals Processing staff currently teach an extractive metallurgy option and one course, Metallurgy 460, Pollution Control in the Mineral Process Industries, has a large waste-water pollution control content.

PROGRAM REQUIREMENTS

Minimum entrance requirements are a recognized bachelor's degree in branch of engineering or science. Included in a students program at the undergraduate level should be mathematics through differential equations, physical chemistry, chemical thermodynamics, elementary geology and mineralogy, and elementary mineral processing.

Students and their research advisors prepare a proposed program of study which is approved by a study panel of three faculty members. The requirements for the M.S. degree include: a minimum of 24 credits of approved graduate courses (6 must be for courses outside the department and 6 credits of reserach); twenty credits must be earned in residence; a satisfactory seminar on research results must be presented; and a research tehsis acceptable to the advisor must be submitted to a committee of faculty members one week prior to the student's oral defense.

The Ph.D. degree does not require any set number of credits but students are normally expected to take a minimum of 15 credits of course work beyond the M.S. degree. Candidates are to demonstrate competence in each of the following areas: general mineral processing; applied surface chemistry; particle technology; and chemical processes, process metallurgy and thermodynamics. A minor field is also required as is proficiency in a language in which a major body of relevant technical literature exists. The candidate must spend at least three terms as a registered students and a comprehensive examination if required prior to the thesis defense.

Assistantships and fellowships are available from the department. Graduate students receive financial assistance primarily from the research contracts. No special university funding exists for students enrolled in the program.

CURRENT FACULTY, STUDENTS, GRADUATES

Three faculty members (2½ full-time equivalent) contribute to the teaching of the program's curriculum. Each member teaches four to five courses annually and they spend about 50 percent of their time in research. Faculty have received research funding for pollution control work from the following sources: American Iron and Steel Institute (Water Pollution from Coal Treatment); Kennedy Van Saum Corporation (use of limestone to prevent sulfur air pollution); and the U.S. Bureau of Mines (Coal preparation discharge).

There are a total of 22 full time students (no females) enrolled in the program excluding five who are finishing their thesis. All are on research contracts, fellwoships or foreign government scholarships. Two sutdnets have annually completed graduate degrees over the past ten year period. With increased enrollment, it is expected that seven students will soon annually receive advanced degrees.

Approximately 25 percent of the program's graduates continue on for further education. The majority of graduates who finish the program and find jobs within industry, later return for continued study. Virtually all graduates are employed in the private sector, either in academia or in industry.

PROGRAM PROJECTIONS

Enrollment is dramatically increasing in the program as the demand for graduates by employers is high. Enrollment in the mining area is large and it is expected that over the next ten year period, Penn State will produce 50 to 100 graduates in minerals processing. Fifty percent of the program's research work currently underway is on developing methods of cleaning coal for more efficient pollution control. The program may eventually offer its own bachelor degree program as there is an urgent need to train coal industry personnel.

One additional faculty member (a process engineer with experience in the mineral industry) is needed for the program but no university authorization is expected for hiring.

Job opportunities are so good for mineral processing students with bachelor degrees in the field that few continue on for advanced degree. This poses a recruitment problem for this program that the development of the B.S. option (minerals processing) in the Mining Engineering Program will only partially solve.

COURSE DESCRIPTION (SELECTED)

313 Elements of Mineral Processing - Sampling, sizing, comminution, physical and chemical separation processes, applications to industrial practice. Pollution control. (3 s.h.)

404 Design of Pyrometallurgical Systems - Physical-chemical basis for the conversion of ore to metal. (3 s.h.)

413 Mineral Processing Laboratory - A laboratory study of the chemical and physical principles involved in practical mineral processing operations. (1 s.h.)

414 Extractive Metallurgy Laboratory - Application of basic principles of thermochemistry, thermodynamics and kinetics to extractive metallurgical processes; illustrative of industrial practices. (1 s.h.)

420 Mineral Process Engineering - Unit operations for the processing of particulate materials: comminution, screening, classification, slurry pumping, thickening, filtration, etc. Application to mineral processing plant design. (3 s.h.)

421 Particle Technology Laboratory - Particle sizing techniques used in mineral separations. (1-3 s.h.)

424 Coal Preparation - Unit operations, flowsheets, and testing methods used in preparation of coal. (3 s.h.)

425 Interfacial Phenomena and Flotation - Surface and interfacial phenomena related to flotation agglomeration, flocculation and dispersion of particles. Application to mineral separation and related processes. (3 s.h.)

426 Hydrometallurgy - Theory, unit operations and engineering principles applicable to the recovery of metals from ores by chemical methods. (2 s.h.)

460 Pollution Control in the Mineral Process Industries - Recycle, utilization and pollution control of air, water and solid wastes from mineral porcessing plants. Pollution control through process modification. (3 s.h.)

501 Interfacial Phenomena in Mineral Systems - Applications of surface phenomena to mineral engineering systems. (3 s.h.)

502 Froth Flotation and Agglomeration - Intensive study of theory and applications fo froth flotation and agglomeration. (3 s.h.)

505 Physical Separations in Mineral Processing - Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal and other methods of mineral processing. (3 s.h.)

506 Mineral Process Plant Design - Process design and economy. Development and quantification of flow sheets. Integration of unit operations. Plant layout, equipment selection and instrumentation. (3 s.h.)

507 Chemical Methods in Mineral Processing - Practice and theory of methods to upgrade ores by chemical treatment including roasting, solubility separations, surface phenomena, and reactions. (3 s.h.)

INSTITUTION: THE PENNSYLVANIA STATE UNIVERSITY

PROGRAM: Mining Technology, Mining Engineering

DEPARTMENT: Mineral Engineering

DEGREE: A.A.S. in Mining Technology
Bachelor of Science (B.S.)
Master of Science (M.S.)
Master of Engineering (M.Eng.)
Doctor of Philosophy (in Mining Engineering)

CONTACT:

Dr. Lee Saperstein
Section Chairman of Mining Engineering
118 Mineral Sciences Building
The Pennsylvania State University
University Park, Pennsylvania 16802
(814) 865-3437

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Mining Engineering is the oldest program in the College of Earth and Mineral Sciences at Penn State. The Department of Mining Engineering was formally created in 1890. The Department of Mineral Engineering was formed in 1970 with two sections: Mining Engineering and Petroleum and Natural Gas Engineering. Penn State is one of the few institutions in the country that grants three advanced degrees in mining engineering within its very flexible graduate program.

The associate degree porgram is offered at Altoona, New Kensington and Fayette campuses. This mining technology program trains mining engineering technicians in both technological and managerial skills. Graduates are trained for supervisory or technical oriented positions. A maintenance option prepares students for the job of maintaining expensive and complex mining machines. Graduates desiring a supervisory position may expect a position in the front ranks as a part of an engineering team with widespread responsibilities for health and safety. Mining technicians are responsible for ventilation surveys, for maintaining sampling programs, for assisting mine engineers in their design programs and for surveying.

The complete four year program leading to the B.S. in Mining Engineering is offered at the University Park Campus. However, mining engineering studies for the first two years can be started at any of the University's Commonwealth Campuses. After two years, the student transfers to the University Park Campus. Mining engineers may be employed as a supervisor or engineer in operations, as an engineer for equipment sales and investment firms or government agencies, as a research scientist, or as a teacher. The B.S. degree mining program provides adequate preparation for the engineer-in-training examination which is the first step toward registration.

The Master of Science, Master of Engineering, and Doctor of Philosophy degrees in mining engineering are offered by the Mining Engineering Section. Areas of specialization which may be followed in research and course work include mine property valuation and economics of mining engineering; mechanization and mine plant development and exploitation methods; mine management, production engineering; operations research, environmental control and health and safety; and rock mechanics. Programs of study for students electing to obtain the Master of Engineering degree in mining engineering are available in general mining engineering, rock mechanics, mine operations, research systems engineering, internal or external mine environmental control, mine health and safety. The Department of Mineral Engineering offers an interdisciplinary graduate program leading to the professional degree of Master of Engineering in mineral engineering management. This program is designed to educate engineers who seek executive positions in the mineral and heavy construction industries.

The Mining Engineering Section also conducts continuing education services for non-degree students. A variety of workshops and short courses are offered to workers in the mining industry. The Section also sponsors a variety of special symposia and conferences each year.

Penn State has assembled some of the best facilities for the use of its mining engineering students and faculty. Among these are surveying gear; automatic gas and dust analyzers in the ventilation laboratory; a photoelastic facility; an automatic test facility; and a 200-channel digital data acquisition system. Details of mine systems are taught through field trips to nearby modern mines in Pennsylvania. Weekly seminars enable students and staff to find out about the programs of each other's research. All research personnel have access to an IBM 370-168 computer.

PROGRAM REQUIREMENTS

In order to be admitted to the associate degree program, a total of 15 Carnegie secondary school units are required (3 math, 2 science, 10 other). Entrance to the College of Earth and Mineral Sciences requires completion of 15 secondary school units (3 English, 3 math, 1 science and 8 other). To enter the advanced degree programs, a bachelor's degree in mining engineering or a related engineering or a related engineering field is required for admission. Students may be required to make deficiencies in their area of specialization. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission.

A total of 70 credits over six terms are required in order to complete the associate degree program. The regular program takes two years to complete allowing one summer off for industrial employemnt. If a student elects to participate in cooperative training, three years may be devoted to the program. During the fourth, fifth and sixth terms, the Production Option is offered at all three of the campuses whereas a Maintenance Option is offered only at the Fayette campus.

For the B.S. degree in Mining Engineering, a total of 137 credits are required. The curriculum has room for 18 credits of courses in social and humanistic studies and six credits in additional technical studies. Sixty-eight baccalaureate degree requirements, 69 credits required for the major, and 6 credits required for the B.S. degree.

A total of 30 credits plus thesis are required in order to earn the M.S. degree. Students who desire to obtain the Master of Engineering degree in mining engineering must take a minimum of 30 credits (including at least 12 credtis at the 500 level) of appropriate courses in the major area and elective courses. A scholarly written report is also required.

Completion of 60 additional credits plus thesis are required for the Ph.D. degree. The communication and foreign language requirement for the Ph.D. degree may be satisfied by completion of courses in two languages or by completion of courses in one language and 6 credits of computer science.

A five-year work-study plan (Student-Trainee Program) is available to Mining Engineering students. This plan alternates employment in industry and education at Penn State. Student-trainees receive the B.S. degree in five years rather than four, following a rearranged major. The U.S. Bureau of Mines has sponsored many students from Penn State in mining engineering. Numerous other mining and manufacturing companies as well as governmental agencies sponsor students in this program.

Pennsylvania residents are eligible to apply to the Pennsylvania Higher Education Assistance Agency for Financial assistance. The College of Earth and Mineral Sciences' scholarship committee nominates candidates for selected scholarships and puts students in contact with non-university sources of aid such as the American Institute of Mining, Metallurgical, and Petroleum Engineers. A total of $30,000 of scholarships are available from all sources each year. Research funds usually provide for one or two half-time graduate assistantships per research project.

CURRENT FACULTY, STUDENTS, GRADUATES

Six faculty members contribute to the teaching of the associate degree program in mining technology. The Department of Mineral Engineering carries a total of 25 faculty members. Included are 17¼ professional rank staff and 6 research assistants or instructors professor rank. Six faculty members are supported entirely by research funding. Research funding comes from a variety of sources which include the U.S. Bureau of Mines, the Department of Energy (ERDA), U.S. Environmental Protection Agency, the American Gas Association, and some private organizations. The U.S. Environmental Protection Agency (Cincinnati - NERC) funded the Department to prepare a premining planning manual for surface mining. The Department has a one million dollar total funding from outside research sources and training grants.

A total of 200 full-time (3-4 females) and 100 part-time miners participate in the associate degree program. There are 350 (12 female) full-time undergraduates enrolled in the B.S. degree program and 25 (2 female) graduate students enrolled in the advanced degree programs. Enrollment at the undergraduate level expecially is increasing from levels of previous years. A total of almost 700 students are enrolled in degree programs at all levels in this field at Penn State.

About 175 students annually graduate with degrees in mining on the average. About 100 students receive the associate degree in mining technology; 65 receive the B.S. degree; five to ten students earn the M.S. degree (depending on research projects or theses); and two students anually receive Ph.D.s. Most students work in the field after receiving the B.S. degree. The associate and M.Eng. degree are designed to be terminal programs whereas the B.S., and M.S. degree programs are not intended to be terminal.

Virtually all graduates find employment in their field. Most (90%) find positions in the private sector and few (10%) find government jobs. Recent graduates have accepted positions in research and in operations for both underground and surface mines at salaries that average among the highest of any university graduates. Approximately 400 mining engineers actually join the mining industry annually and the yearly need, both to replace those leaving and to provide for expansion, is estimated at over 1,000 mining engineers. Positions within the Federal government can be found mostly with the U.S. Bureau of Mines, Mine Safety and Health and Office of Surface Mining. Others are hired by such agencies as the U.S. Internal Revenue Service, the U.S. Bureau of Land Management, the U.S. Forest Service and the U.S. Geological Service, to perform research, safety, inspection, and evaluation functions. Mining engineers also hold jobs with various divisions of state and local governments.

PROGRAM PROJECTIONS

The mining engineering program is definitely marked for expansion. Development of a mineral processing option is being considered as part of the B.S. program in mining engineering. Evnironmental emphasis in this field is increasingly important and the passage of the recent strip mining bill is an excellent example and some changes will be felt as a result. Additional hydrology courses for the study of water flow may be later incorporated into the program.

COURSE DESCRIPTION

(the following is a partial listing of courses)

MNG 30 Introduction to Mining Engineering - Examination, development, and exploitation of mineral deposits in case studies of mineral deposits and mines; unit operations, cycling, equipment, methods. (3 s.h.)

MNG 400 Mining and Our Environment - For nonmining students. Nontechnical treatment of mining methods, practices, and role in today's civilization; socioeconomic and environmental problems. (3 s.h.)

MNG 422 Mine Ventilation and Air Conditioning - Quality, quantity, and temperature-humidity control of the mine atmosphere; general mine environmental control. (3 s.h.)

MNG 441 Surface Mining Systems and Design - Design of surface mining for coal and non-coal minerals:unit operations, systems, slope stability, planning parameters, reclamation, legal requirements. (3 s.h.)

MNG 451 Advanced Mining Engineering - Exploration, examination, exploitation, and valuation of an assigned mineral property; layour of mining method; selection of equipment; cost estimation. (1-3 s.h.)

MNG 513 Mine Cost Analysis - Nature of mining costs, their analysis and control: depreciation and depletion, capital and operating costs, budgets, records. (3 s.h.)

MNG 514 Mine Operations Analysis - Application of operations research techniques in determining optimal design and operating policies for mine management. (3 s.h.)

MNG 543 Strata Control Engineering - Theoretical considerations; convergence, abutments, subsidence; rockbursts; underground support systems; design of drill rounds. (3 s.h.)

MNG 580 Mining Engineering Research - Supervised research on a specific problem involved in mining science or technology. (1-3 s.h.)

MN PR 501 Interfacial Phenomena in Mineral Systems - Applications of surface phenomena to mineral engineering systems. Thermodynamics of surfaces, flotation, adsorption of detergents, electrical double layer, flocculation, dispersion. (3 s.h.)

MN PR 502 Froth Flotation and Agglomeration - Intensive study of theory and applications of froth flotation and agglomeration. (3 s.h.)

MN PR 508 Mineral Particle Systems - Creation, characterization, separation and agglomeration of particles. Comminution, sizing, fractionation of powders; surface area, pore size determinations. (3 .sh.)

INSTITUTION: THE PENNSYLVANIA STATE UNIVERSITY

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Engineering

DEGREE: Bachelor of Science in Nuclear Engineering
Master of Science in Nuclear Engineering
Master of Engineering in Nuclear Engineering
Doctor of Philosophy

CONTACT: Dr. Warren F. Witzig
Head of Nuclear Engineering Department
231 Sackett Building
The Pennsylvania State University
University Park, Pennsylvania 16802
(814) 865-4911

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The Nuclear Engineering Department first offered an M.S. program in 1959 following acquiring a research reactor and associated facilities from support provided by President Eisenhower's "Atoms for Peace" program in 1955. The baccalaureate degree program was first initiated in 1968. Undergraduates receive instruction in energy removal and conversion, neutron physics, materials science, instrumentation and control, and chemistry. Emphasis in the program is on the environmental interfaces, the fuel cycle, cost-benefit criteria, and quality assurance.

Nuclear engineers can obtain positions in research, development, design, manufacture, or operation of nuclear systems, including nuclear fission reactors, fusion devices, and radioisotopic generators.

The College of Engineering of the Pennsylvania State University and the Graduate School of Public Health of the University of Pittsburgh have developed a joint five-year program leading to a Bachelor's Degree in Nuclear Engineering and a Master's degree in Radiation Health. Students enter the program at the University Park campus as freshman enrolled in Nuclear Engineering. At the satisfactory conclusion of a normal four-year program, the students graduate with a degree in Nuclear Engineering. Those eligible will then be admitted upon application, to the Radiation Health Department of the Graduate School of Public Health of the University of Pittsburgh. At the University of Pittsburgh, courses can be selected in Health Physics, Radiation Biology, and Medical

Applications. Within eleven months upon entering the graduate program a master's degree in Radiation Health (M.Sc.Hyg.) can be earned.

The Nuclear Engineering Department has one of the most complete and modern university reactor facilities in the United States. The laboratory complex includes the Penn State TRIGA MARK III Reactor, the Combalt-60 Radiation Facility, two hot cells, a radiochemistry laboratory, an extensive array of radiation sources and counting equipment, and much more. The Department is currently constructing a new fast reactor subcritical assembly.

PROGRAM REQUIREMENTS

In order to enter the undergraduate program in the College of Engineering, three secondary units of English, three units of math, one unit of science, and eight units of other courses are required. The mathematics requirement includes 1½ units of algebra, one unit of plane geometry, and ½ unit of trigonometry. To enter the graduate program, students with a 2.50 junior-senior average and with an appropriate course background will be considered for admission.

The undergraduate program requires 21 required credits in Nuclear Engineering and six additional credits in the Nuclear Engineering option. Additional courses in engineering, chemistry, physics, math, and humanities complement and supplement the nuclear engineering core. A total of 137 credits are required to earn the B.S. degree in Nuclear Engineering.

A minimum of 30 credits is required for the Master of Science degree and students may decide whether to prepare a scholarly paper or a research thesis. The thesis is worth six credits. Six credits of graduate courses in the major field may be taken to earn the M.S. without thesis.

The Master of Engineering degree also requires a minimum of 30 creits but no thesis. Instead, an engineering paper about a selected phase of engineering is prepared and corresponds to a typical first assignment to an engineer working in industry.

The Ph.D. degree requires 55-65 credits of 400-500 level courses plus about 30 credits of Nuclear Engineering 600 courses. The doctorate program is worked out in conjunction with the major advisor and the Ph.D. doctoral committee. One half of the course credits are in math, physics, and a minor engineering field, and the other half are composed of Nuclear Engineering Department courses. The major requirements for the Doctor of Philosophy candidate are:

1. Successful completion of a candidacy examination.
2. Demonstrated proficiency in two languages pertinent to his/her Ph.D. program. One of these must be English.

3. Successful completion of a comprehensive examination.
4. Completion of a doctoral thesis.
5. Successful completion of a final oral examination on the thesis work.

B.S. degree students may participate in a co-op program with architectural engineering firms and utilities. Only one to two students are involved in this program. In the spring term the department takes a field trip to several nuclear power installations. Several seminars are scheduled during the year and both undergraduates and graduate students are encouraged to attend.

The traditional sources of financial aid (loans, scholarships, federal programs) are available to undergraduates. The Nuclear Engineering Department has several half-time assistantships available which includes a stipend and a grant-in-aid to cover all tuition. Two Department of Energy funded traineeships are available. Trainees carry five to seven course credits perterm receive stipends, and usually receive grants-in-aid.

CURRENT FACULTY, STUDENTS, GRADUATES

Sixteen faculty members teach the department's curriculum Faculty devote about 20 percent of their time to research activities. Two faculty members are supported entirely by research funding. Most research funding comes from the Department of Energy, the National institutes of Health and from utilites. Current environmental related research includes thermal pollution control, SO_2NOX particulate removal, and effects of radiation on boiling.

There are currently (Fall, 1977) 180 students enrolled in the B.S. degree program of whom about nine (5%) are female. About 40 students (no females) are enrolled in advanced degree programs. There are very few part-time students enrolled at Penn State primarily because of the remoteness of the University Park Campus. It is estimated that 40 students annually receive the B.S. degree and 18 students receive advanced degrees. Enrollment has increased slightly since the Fall Term, 1976.

Students earning baccalaureates in the program are encouraged to apply to other educational institutions for higher degrees. Approximately twenty percent of the baccalaureate and masters graduates continue on for advanced degrees. Department officials estimate that two thirds of the Department's graduates obtain jobs in the private sector (industry, utilities, consulting) and one-third find positions in government. A survey was conducted of 42 1976-1977 baccalaureate graduates and it was found that: 22 were employed by industry; 2 are in the military; 6 are attending graduate school, and the status of 12 are unknown.

PROGRAM PROJECTIONS

It is not anticipated that the program will undergo significant changes within the foreseeable future other than common evolutionary modifications. Within the next five to ten years, it is anticipated that the number of faculty may increase by ten percent or two persons. Increased emphasis may be taken in nuclear medicine, environmental impact analysis, computer modelling, and pathways demand for radioisotope transport.

COURSE DESCRIPTION

(the following is a partial listing of courses)

Undergraduate courses:

NucE 200 Elements of Nuclear Engineering - Introduction to analytical and experimental aspects of nuclear engineering. (3 s.h.)

NucE 405 Applied Nuclear and Radiochemistry - Fundamentals and interdisciplinary applications of Nuclear and Radiochemistry with laboratory work using a variety fo radiation measurement instruments. (3 s.h.)

NucE 420 Radiological Safety - Ionizing radiation, biological effects, radiation measurement, dose computational techniques, local and federal regulations, exposure control. (3 s.h.)

NucE 428 Radioactive Waste Control - Nature, sources, and control of radioactive wastes; theory and practice of disposal processes. (3 s.h.)

Graduate courses:

NucE 507 Interaction of Radiations with Matter - Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. (3 s.h.)

NucE 509 Radiation Damage in Solids - Production of defects by high-energy particles; nature of defects; diffusion and annealing in solids; macro property changes. (2 s.h.)

NucE 511 Nuclear Reactor Materials - Philosophy, selection, technology, use economics, and performance of materials of major interest in nuclear power reactors today. (3 s.h.)

NucE 520 Reactor Analysis - Physical principles and mathematical methods of reactor analysis. (3 s.h.)

INSTITUTION: THE PENNSYLVANIA STATE UNIVERSITY

PROGRAM: Nuclear Engineering Technology

DEPARTMENT: General Engineering

DEGREE: Associate Degree in Nuclear Engineering Technology

CONTACT: Dr. Warren F. Witzig
Head, Department of Nuclear Engineering
231 Sackett Building
The Pennsylvania State University
University Park, Pennsylvania 16802
(814) 865-4911

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

This two-year associate degree program was initiated in the fall of 1970 at the University's Altoona Campus with the Hazleton and McKeesport Campuses aiding the program in the fall of 1974. The program's sixth term is taken at the University Park Campus. The program is designed to train versatile, well-equipped nuclear technicians who can quickly become valuable and effective members of engineering and reactor operations teams. Nuclear technicians assist professional engineers in radiation safety, reactor operations, radiosotope handling, nuclear and control instrumentation, fuel fabrication, and health physics. They perform routine research, development, testing manufacture, and maintenance tasks.

While at the Altoona and other campuses, the student receives specialized instruction in mathematics, physics, electricity and electronics, chemistry,and communications. During the sixth term at the University Park Campus, the Nuclear Engineering Department faculty provides instruction. Extensive use if made of the Breazeale Nuclear Reactor Facility to familiarize students with the components and systems in a nuclear power plant.

PROGRAM REQUIREMENTS

Applicants to the program are required to have completed fifteen Carnegie units of preparatory work at an accredited secondary school. Graduates of three-year senior high schools need only twelve units of work. Required are three units of English and two units of mathematics. One unit of mathematics must be in algebra and the other in any combination of advanced algebra, plane geometry, solid geometry; or trigonometry.

A total of 73 credits completed are required to earn the Associate Degree in Nuclear Engineering Technology. Students take over the six required terms courses in English, mathematics, physics, computer science, chemistry, electrical engineering, mechanical engineering, speech communication, and nuclear engineering. Electives are required in humanities and in the social sciences. Sixth term lectures by faculty of the Nuclear Engineering Department cover various reactor types, with emphasis on fuel heat removal and power generation, shielding, fuel fabrication, reprocessing control systems, steady-state reactor theory, and reactor safety. Laboratory sessions provide "hands-on" experience with basic reactor experiments and radiation measurements. Students take 12 credits of Nuclear Engineering during the Sixth Term.

Institutional aid (scholarships and loans) or federal aid (Supplemental Educational Opportunity Grants,etc.) are available to students. A limited number of freshman scholarships are awarded to some students.

CURRENT FACULTY, STUDENTS, GRADUATES

Faculty from the General Engineering Department and the Nuclear Engineering Department cooperate in presenting instruction to students enrolled in the program. Because the courses are offered at a variety of campuses, it is not possible to determine how many faculty are involved in teaching the curriculum.

There are currently 30 students enrolled in the Nuclear Engineering Technology Program (3-4 female). This represents a sizable decline from the total enrollment of 61 during the fall term, 1976. The May, 1977 graduates numbered 20.

Ninety percent of the program's graduates enter the job market and ten percent continue on for higher degrees at Penn State's University Park Campus. About 67% find jobs in the private sector (industry, utilities, and architectural engineering firms) and 33% find positions in the government. Employment for graduates is tending to be increasingly difficult to obtain and is radically different from the situation three years ago in which the anchorman graduate had three job offers by the time he or she graduated.

PROGRAM PROJECTIONS

Reactor construction and operation continue at a high level, which assure a stable enrollment and graduate projection for this program.

COURSE DESCRIPTION

800 Nuclear and Atomic Science - Introduction to the theories of atomic and nuclear structure and electromagnetic radiation. (2 s.h.)

801 Radiological Safety - Discussion of basic radiation dose units, radiation monitoring techniques, biological effects of radiation, and AEC regulations. (2 s.h.)

802 Elements of Nuclear Technology - Study of nuclear radiations, nuclear interactions, neutron diffusion, and reactor materials. (2 s.h.)

803 Elements of Nuclear Power Generation - Survey of various reactor types with emphasis on fuel heat removal and power generation, shielding, fuel fabrication and reprocessing. (3 s.h.)

804 Introduction to Reactor Technology - Steady state reactor theory, kinetic behavior of reactors and reactor control systems. (3 s.h.)

805 Principles of Measurement - A study of measurement in the nuclear industry, including the instruments used, accuracy of measurement, and statistical justification. (3 s.h.)

812 Nuclear Technology Laboratory - Laboratory study of radiation measurements and the diversified application of nuclear techniques. (3 s.h.)

814 Reactor Technology Laboratory - Laboratory study of basic reactor experiments, control rod calibration, critical experiment, etc. (3 s.h.)

830 Selected Topics in Nuclear Engineering Technology - Individual group work in nuclear engineering technology for students with specific occupational objectives. (3 s.h.)

INSTITUTION: THE PENNSYLVANIA STATE UNIVERSITY

PROGRAM: Petroleum and Natural Gas Engineering

DEPARTMENT: Mineral Engineering

DEGREE: Bachelor of Science (B.S.)
Master of Science (M.S.)
Doctor of Philosophy (in Petroleum and Natural Gas Engineering)

CONTACT: Dr. C. Drew Stahl
Section Chairman of Petroleum and Natural Gas Engineering
25 Mineral Industries Building
Pennsylvania State University
University Park, Pennsylvania 16802
(814) 865-6082

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The Petroleum and Natural Gas Engineering Section began as an academic curriculum in 1932 out of considerable interest in petroleum production on the part of several members of the faculty of Geology Penn State is the only university in the Northeast to offer all three academic degrees (B.S.,M.S.,Ph.D.) in this field. Penn State has achieved worldwide repute for its work in reservoir modeling.

The four-year baccalaureate program is divided into two equal functional segments. The first portion is concentrated on a core of courses taught in other departments and colleges of the university. The academic program for the first two years may be started at any of the Commonwealth campuses. The second portion is concentrated on courses dealing with the major and must be taken at the University Park Campus during the third and fourth years of the baccalaureate program. Students enrolled in this major are prepared for careers in the oil and gas production industries. Graduates are trained to work in the reas of production, transportation, evaluation, and storage of oil and natural gas. Positions may be found with major oil and gas companies, governmental agencies, and banking institutions.

The Petroleum and Natural Gas Section was the first department in the country to offer both the Master of Science and the Doctor of Philosophy degrees. The program features a high degree of flexibility and areas of specialization include:experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems. Graduates are qualified for positions as petroleum engineers, drilling engineers, production engineers, secondary recovery engineers, reservoir engineers, and sales engineers. Most graduates find positions with oil and gas producing companies although positions are also available in governmental and regulatory bodies.

The program has extensive laboratories and test equipment facilities for work in coring, core analysis, fluid flow and phase behavior. Students also make field trips to several producing areas in Pennsylvania. Numerous speakers come to Penn State from industry to address meetings of petroleum engineering students.

PROGRAM REQUIREMENTS

In order to enter the College of Earth and Mineral Sciences as an undergraduate, applicants must have completed three secondary units of English, three units of mathematics (1½ units of Algebra, 1 unit of plane geometry, and ½ unit of trigonometry) and one unit of science (physics). Students who expect to enter graduate study in this program with a degree in another major should present 6 credits in geology, 15 in engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission. Few applicants are taken into the graduate program with less than a 3.0 (B) average in their undergraduate work.

For the B.S. degree in Petroleum and Natural Gas Engineering, a total of 137 credits are required. Of the total, 77-78 credits must be baccalaureate degree requirements and 59 credits are required for the major. Major courses are arranged in two parallel sequences - reservoir engineering and drilling production. The curriculum allows 18 credits of social and humantarian studies and nine credits of elective technical studies. Included in the elective technical studies courses is PNG 400, Undergraduate Thesis. The thesis program for undergraduates provide students an opportunity to acquire research skills and techniques while doing original research work of interest to them. It is particularly valuable to undergraduate planning to enter advanced-degree programs in petroleum engineering. Courses in geological science and the application of the basic sciences to petroleum and natural gas production distinguishes the baccalaureate program.

A minimum of 30 credits beyond the baccalaureate degree must be completed for the Master of Science degree in Petroleum and Natural Gas Engineering. To earn the doctorate, completion of an additional 60 credtis plus thesis is required. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language. Students in this program may elect the dual-title degree program option in operations research for the Ph.D. and M.S. degrees.

Oil and gas companies have a strong summer employment program of students. Although the section has no formal cooperative programs as such, it is common for students to spend several summers working for oil companies throughout the country. The companies have an active recruitment program on campus to attract students for summer employment.

Pennsylvania residents are eligible to apply for financial aid from the Pennsylvania Higher Education Assistance Agency. The section has an active scholarship program supported by companies throughout the country. These sponsored scholarships (24-25) are awarded on the basis of scholarship and need and are normally renewable from year to year providing the recipient maintains a good scholastic average. Research funds usually provide for one or two half-time Graduate Assistantships which are awarded to outstanding students.

CURRENT FACULTY, STUDENTS. GRADUATES

Seven full-time faculty members contribute to the offering of the section's curriculum. Most spend half-time teaching and the other one-half of their time in research. None are entirely supported by research funding as there are few research professorships at Penn State. Funds for research projects are obtained by individual faculty members by proposal to various funding agencies and founcations (ERDA, U.S. Bureau of Mines, Commonwealth of Pennsylvania, oil companies, etc.). Recent funding has been granted for increased oil recovery and for problems dealing with advanced recovery techniques.

There are currently (fall,1977) a total of 135 students (6 females) enrolled in the baccalaureate program and all are full-time. A total of 29 students (1 female) are enrolled in the M.S. degree program. Enrollment in the undergraduate program is rapidly increasing due to the market demand for students in this field.

Approximately 35 students annually earn baccalaureate degrees on the average in Petroleum and Natural Gas Engineering (1977 - 35, 1978 - 40). It is estimated that five to six students annually receive the M.S. degree and one student earns the Ph.D.

Because there are many well paying jobs for B.S. graduates, few continue on for the M.S. degree in Petroleum and Natural Gas Engineering. It is not uncommon for each B.S. student to receive ten job offers. Most that do continue on for the M.S. degree, continue on at Penn State. Virtually all graduates obtain employment in their field and most (90%) find jobs in the private sector, mostly with the U.S. Federal Power Commission and the U.S. Geological Survey.

PROGRAM PROJECTIONS

The field of petroleum engineering has always had a strong demand for graduate engineers and the demand is expected to continue to grow stronger. The current demand for baccalaureate engineers is approximately 500 per year at the minimum.

This program is definitely expected to attract additional students. The emphasis in the program may be later oriented more into off-shore oil and gas operations and waste disposal. A much greater emphasis on waste disposal is expected to develop because of the federal governmental pressures demand for knowledge in this area. Within the next two years (1978-1979), two additional petroleum engineers are expected to be recruited with expertise in these two areas (off-shore operations, waste disposal).

COURSE DESCRIPTION

(the following is a partial listing of courses)

100 Petroleum, Natural Gas, and Man - Historical survey of the petroleum industry. (3 s.h.)

410 Applied Reservoir Engineering - Analysis and prediction of reservoir performance by use of material balance and steady and non-steady state flow equations. (3 s.h.)

421 Reservoir Engineering - Reservoir fluid properties, reservoir rock properties, flow behavior in reservoir rocks, displacement of oil, and standard reservoir engineering methods. (3 s.h.)

481 Natural Gas and Gasoline Plants - Production, analysis, measurement, and transmission of natural gas; manufacture of natural gasoline and study of condensate fields. (2 s.h.)

493 Engineering Evaluation of Oil and Gas Properties - Reserves, decline curves, conservation, value and cost of money, property transactions, evaluation yardsticks, depreciation, depletion, allowance, income tax calculations. (3 s.h.)

514 Optimization of Petroleum Recovery Processes - Optimum search methods, linear programming, nonlinear programming, dynamic programming, application to water-flooding, depletion drive, steam injection, gas cycling, miscible displacement. (3 s.h.)

515 Advanced Oil Recovery Techniques - Advanced oil recovery techniques including water-flooding, in situ combustion, steam injection, hot-water injection, and miscible-phase displacement. (3 s.h.)

519 Design of Thermal Recovery Projects - Suitability of reservoirs for thermal oil recovery; case histories; design of in situ combustion and steamfloods; thermal stimulation; shale oil recovery. (3 s.h.)

520 Phase Relations in Reservoir Engineering - Phase relations as applied to condensate and retrogade condensate reservoirs and to other problems in petroleum production. (3 s.h.)

530 Natural Gas Engineering - Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycle; current developments. (1-3 s.h.)

550 Advanced Engineering Evaluation of Oil- and Gas- Producing Properties - Selected topics of current research and development interest in formation evaluation, geophysical well logging and production economics. (3 s.h.)

INSTITUTION: UNIVERSITY OF CALIFORNIA, BERKELEY

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Engineering

DEGREE: Bachelor of Science (B.S.), Nuclear Engineering; Master of Science (M.S.), Engineering; Master of Science (M.S.), Engineering Science; Master of Engineering (M.E.), Doctor of Philosophy in Engineering (Ph.D.); Doctor of Engineering (D.E.)

CONTACT:
Dr. Thomas H. Pigford
Chairman, Department of Nuclear Engineering
Etcheverry Hall, Room 4101
University of California, Berkeley
Berkeley, California 94720
(415) 642-6469

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Nuclear engineering at Berkeley began in 1957. The program continued to evolve and in 1972, an undergraduate degree in nuclear engineering was offered. Still, there was no separate major in nuclear engineering for the undergraduate but rather a student was required to major in another field of engineering. For example, a student would major in civil and nuclear engineering or mechanical and nuclear engineering. Today, there are five double major options for students interested in nuclear engineering at the undergraduate level. They are: materials science and engineering/nuclear engineering; civil/nuclear engineering; electrical and computer sciences/nuclear engineering; industrial and operations research/nuclear engineering; and, mechanical/nuclear engineering. All programs may be completed in four years. Students selecting a double major program have two advisors, one from each of the two major fields. In 1977, a separate baccalaureate program in nuclear engineering began, and today, students may earn a B.S. in nuclear engineering upon successful completion of the requirements.

Graduate study in nuclear engineering can be carried out in one of three ways. Students choosing to place emphasis on the application of the natural sciences and the analysis and solution of engineering problems will follow Option I, the Master of Science and Doctor of Philosophy in Engineering. Option II leads to the Master of Science and Doctor of Philosophy in Engineering Science in which emphasis is placed upon the theoretical principles upon which engineering is founded. Advanced courses in mathematics, chemistry, physics, and the life sciences, are normally included in such programs. Graduates of the life sciences and other non-engineering fields who are interested in basic research in a field of engineering or engineering science are eligible to participate in the program. The third option is designed for students with strong engineering backgrounds. Emphasis is placed on the technical, sociological, environmental and economic problems involved in the design, construction and operation of engineering structures, processes and equipment. The program leads to the Master of Engineering (M.E.) and the Doctor of Engineering (D.E.)

The graduate program is divided into five major areas, each representing an important aspect of nuclear technology. The five areas are: reactor analysis; nuclear reactor engineering; chemistry and materials in nuclear technology; applied nuclear reactions and instrumentation; and, radiation protection and environmental effects. Required undergraduate preparation includes mathematics through partial differential equations and advanced analysis, nuclear physics and thermodynamics. The department is most noted for its work in thermal hydraulic analysis, nuclear materials, nuclear fuel cycle analysis and nuclear fussion technology.

The nuclear engineering laboratory is very well equipped. Facilities include a high-flux pulsed reactor, a graphite subcritical assembly, two pulsed neutran generators, a I MEV Van de Graaff accelerator, several multi-channel pulse height analyzers and professionally staffed electronic and machine shops.

PROGRAM REQUIREMENTS

Because the bachelor program in nuclear engineering began this year, the specific program requirements are not available at this time. Double major students are expected to complete 28 quarter units of humanistic social studies of which nine must be in upper division courses. The electives must include sufficient units of upper division courses in nuclear engineering so that the upper division nuclear engineering courses total at least 20 units.

The M.S. degree in engineering or engineering science may be completed under Plan I or Plan II. Plan I carries minimum requirements of 30 quarter units plus a thesis. Of the 30 units, 12 must be graduate work in the major subject and no more than three units of credit for independent study or research courses. The remaining 18 units must be graduate or advanced undergraduate courses organized in a logical program of study with faculty approval. Plan II requires a minimum of 36 quarter units plus a comprehensive final examination. At least 18 units must be strictly graduate courses in the major subject with no more than three units of credit for individual study and research courses. The remaining 18 units may be in approved graduate or advanced undergraduate courses.

Requirements for the Master of Engineering degree include a minimum of 60 quarter units consisting of approved upper division, graduate and professional courses. Of the 60 units, 24 to 30 must be oriented toward design and analyses, of which 18 units must be strictly graduate major subject courses. Students must also complete 12 units of graduate or advanced undergraduate courses in technical fields unrelated to the major subject in order to provide technical breadth. At least 12 units of advanced undergraduate or graduate courses in the social sciences or humanities are also required. The remaining 12 to 16 units must be at the graduate level in professionally oriented individual study or research, carried out under the supervision of a faculty member, culminating in a written report.

Advancement to doctoral studies is normally realized after completion of the requirements for a master's degree. The student is required to complete course work in his major field of study, two minor fields, and a thesis. A minimum of 50 quarter units of formal courses (approved by the major advisor) is considered necessary to fulfill the major and minor requirements.

CURRENT FACULTY, STUDENTS, GRADUATES

The number of faculty in nuclear engineering totals 12. At present, there are eight full professors, two associate professors, one senior lecturer and one lecturer. The program is research oriented and faculty members devote over 30% of their time to research projects. Only the two lecturers are supported by research grants and therefore, have light teaching responsibilities. The remaining 10 faculty are cost-centered.

Undergraduate enrollment in the program has increased slightly over the last few years, with 120 double majors in nuclear engineering. The number of double major graduates per year is 86. The separate program, the Bachelor of Nuclear Engineering, which began this year, has fewer than 20 students. There have been no graduates of the program as yet.

The enrollment for the Master of Science degree in nuclear engineering is approximately 22. The program graduates, on the average, 15 students per year. Enrollment of the Master of Science in Engineering Science is comparable to the M.S. program with 22 students enrolled and approximately 15 graduates per year. The Master of Engineering program is small with only two students enrolled and one graduating each year.

The Ph.D. program at UC, Berkeley, is one of the largest nuclear engineering programs in the country. At present, 43 students are enrolled in the program with an average of nine graduates per year. Although the Doctor of Engineering (D.E.) degree is offered, a D.E. degree has not been conferred in many years.

Students are not actively recruited for the program. However, brochures are sent out to various undergraduate schools describing the graduate program. Approximately 30% of the undergraduate students in nuclear engineering are foreign students. Of the U.S. students, over 60% are from in-state and 20% elsewhere. The graduate program has a foreign enrollment of 40%. Students from within the U.S. are distributed as follows: 20% in state and 40% out-of-state.

Undergraduates in need may apply for general financial aid. Outstanding students are likely to receive university scholarships. Financial support for graduate students is in the form of fellowships, teaching assistantships, training grants from DOE and a large number of research assistantships.

The majority of undergraduates (70% to 80%) continue their studies at the graduate level. Those seeking employment find jobs in industry or consulting. Graduate students find employment with governmental agencies (50%), private industry (20%), consulting firms (10%) or university positions (20%).

PROGRAM PROJECTIONS

The Nuclear Engineering Department at Berkeley is one of the top three in the country. At present, there are no major plans to expand or change the program. There is a need, however, for more work in structural analysis of nuclear reactor cores and environmental radiology. Depending on need, a M.S. program in Environmental Radiology may be developed within the next five years.

COURSE DESCRIPTION (selected)

Upper division courses:

NE 101 Nuclear Reactions and Radiation - Nuclear properties, elements of nuclear structure, radioactivity, interactions of radiation in matter, neutron reactions, fission, fusion, practical consequences and applications. (4 q.h.)

NE 122 Thermal and Irradiation Behavior of Crystalline Solids - Fundamental aspects of the thermal, structural and irradiation properties of metals and ceramics. (4 q.h.)

NE 150A-150B Introduction to Nuclear Reactor Theory - Neutron interactions, nuclear fission and chain reacting systematics in thermal and fast nuclear reactors. (4,3 q.h.)

NE 160A-160B Nuclear Power Engineering - Engineering analysis in the design of nuclear fission power reactors and systems. Emphasizes thermal and structural design of reactor cores and plant components. (4,4 q.h.)

Graduate courses:

NE 224 Process Technology in the Nuclear Fuel Cycle - Ex-reactor components of the nuclear fuel cycle; uranium availability, production of uranium and fabrication of nuclear fuel elements. (4 q.h.)

NE 240 Biological Effects of Radiation and Radiation Safety - Safety criteria. Effects of charged particle and gamma radiations on cells and cell growth. (4 q.h.)

NE 265 Design Analysis of Nuclear Reactors - Principles and techniques of economic analysis to determine capital and operating costs. (4 q.h.)

NE 267 Engineering Aspects of Nuclear Reactor Safety - Methods used in safety evaluation of large nuclear power plants. Safety philosophies and design criteria. (3 q.h.)

INSTITUTION: UNIVERSITY OF FLORIDA

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Engineering Sciences

DEGREE: Bachelor of Science (Nuclear Engineering Sciences)
Bachelor of Science in Engineering (Nuclear Engineering)

CONTACT: Dr. E. E. Carroll, Jr., Chairman
Department of Nuclear Engineering Sciences
University of Florida
Gainesville, Florida 32611
(904) 302-1401

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Nuclear engineering sciences comprises those fields of engineering and science which are directly concerned with the release, control, and safe utilization of nuclear energy. Programs are available which prepare individuals broadly in the design, development, and control of nuclear systems as applied to the use of radiation in medicine, environmental sciences, energy production, and related areas.

Two undergraduate degrees are offered in this department. Students who are interested in pursuing a nuclear science oriented program and who expect to continue their studies at the graduate level typically opt for the B.S. (N.E.S.) degree program, which allows for further specialization in line with the student's professional objectives. This program was begun in 1958.

The B.S.E. (N.E.) began in 1966 and was accredited by the Engineers' Council for Professional Development in 1971 (one of sixteen accredited nuclear engineering undergraduate programs in the country). Nuclear power engineering is the major emphases of this program. Depending on the student's choice of electives, one may emphasize nuclear power engineering, radiation safety, nuclear instrumentation, power management, and radioisotope applications.

Students have access to a full complement of experimental facilities. These include: a 100 KW training reactor, a 4 MeV Van de Graaff accelerator, an IBM-1800 digital computer for on-line data aquisition and analysis, two analog computers, a hybrid computer facility, two subcritical assemblies, two neutron generators, plasma and MHD research facilities as well as a large inventory of specialized nuclear instrumentation.

PROGRAM REQUIREMENTS

Students wishing entrance to the University of Florida should have high school diplomas or the equivalent representing the completion of college preparatory curricula. They must also submit satisfactory scores received on college entrance examinations (i.e., Florida Twelfth Grade Tests, ACT, or SAT).

Both the B.S. (N.E.S.) and the B.S.E. (N.E.) require eighty-seven units of pre-engineering courses. This requires courses in humanities, basic sciences and mathematics, computer programming, an introduction to engineering, and others. Both require two hundred and two quarter credits for graduation.

The B.S.E. (N.E.) degree requires forty units of specific nuclear engineering science courses. These are: NES 401, 402, 403 - Nuclear Engineering 1, 2, and 3; NES 404 - Nuclear Engineering Laboratory 1; NES 405 - Thermodynamics, Heat and Mass Transfer in Nuclear Systems; NES 430 - Applications of Nuclear Radiation and Energy 1; NES 435 - Interaction of Radiation with Matter; NES 440 - Nuclear Instrumentation Systems; NES 451 - Nuclear Power Reactor Design; NES 470 - Advanced Concepts for Nuclear Energy. Forty-five credits which are primarily concerned with design engineering, eight units of free electives, eleven units of engineering science electives, and eleven units of design or technical electives round out the B.S.E. (N.E.) major.

Students who wish to pursue a B.S. (N.E.S.) must complete NES 400 - Principles of Nuclear Reactors, NES 435 - Interaction of Radiation and Matter, and NES 496 - Special Problems in NES. They must then elect a topic for specialization. Typical options are Nuclear Radiation Protection, Nuclear Interactions, Nuclear Plasmas and Fusion. A list of courses from which students may select twenty quarter hours of specialization follows in the COURSE DESCRIPTION. In addition to the specialization courses, students must select forty-four units of other electives. Thirty-one hours of engineering-related courses complete this major.

CURRENT FACULTY, STUDENTS, GRADUATES

Eleven full-time faculty and one split appointment with the Department of Physics compose the staff of the Department of Nuclear Engineering Sciences. Approximately 75-80 percent of their efforts is devoted towards teaching, and the remaining 20-25 percent is designated for research.

Because students do not declare their majors before the beginning of their junior year, enrollment figures are not available prior to this. Since 1971, undergraduate enrollments have more than quadrupled to the current level of one hundred and fifty full-time students. Twelve of the undergraduate students came to this program from mideastern countries and nearly 60 percent are graduates of junior colleges.

Financial aid exists for a few of these students. The Florida Power Company sponsors a few scholarships available on a competitive basis to students in the College of Engineering. Through the university coop program, five students have been placed in the Savannah River Plant, the Florida Shipyard, and various other southern nuclear energy facilities. NROTC provides support for a number of students. This program results in the degree plus a military commission.

Approximately forty-five people graduated in 1977. While a formal follow-up study of graduates is not conducted, it is known that 33-40 percent continue in graduate programs (half at the University of Florida). These graduates are qualified in a variety of areas, among them: reactor operations, nuclear engineering, public utilities - administration, with architectural engineering firms, quality controls and marketing, instrumentation design, and the military (which accounts for about 10 percent of the graduates).

PROGRAM PROJECTIONS

Development of a thermonuclear engineering faculty is currently under way. This will be an additional option for specialization.

Primarily, efforts will continue to be focused on the departmental objectives, which are to provide quality education in the fields of nuclear energy and radiological sciences and to educate engineers/scientists for the relevant technical communities both in the state and in the nation; to conduct competent research programs appropriate to near and long-term state and national needs in nuclear energy, radiological sciences, and related energy fields; and finally, to sustain a strong nucleus of expertise in the fields of nuclear energy and radiological sciences for the service and benefit of the citizens and relevant industries of Florida.

ADDITIONAL INFORMATION

The American Nuclear Society has given the University of Florida's chapter of its student society the Glasstone Award for excellence for four out of the past seven years (this award may not be given to the same institution two years in a row).

COURSE DESCRIPTION

NES 300 Survey of Nuclear Technology in Modern Life - Impact of nuclear technology on our society. Fundamentals of nuclear fission and fusion processes with applications. (3 q.h.)

NES 301 History of Nuclear Energy - Evolution of nuclear weapons in World War II, change from military to civilian control, and maturation of nuclear power. (4 q.h.)

NES 400 Principles of Nuclear Reactors - Introduction to nuclear reactor concepts, instrumentation, operation, fuels, materials, shielding, power generation for non-nuclear engineering major. (4 q.h.)

NES 401 Introduction to Nuclear Engineering 1 - Elementary study of neutron reactions, neutron diffusion, multiplication factors for simple nuclear reactors, and time dependent behavior of nuclear systems. (4 q.h.)

NES 402 Introduction to Nuclear Engineering 2 - Continuation of NES 401. Study of elementary reactor control and instrumentation, radiation effects, nuclear materials, biological effects of radiation, health regulations. (4 q.h.)

NES 403 Introduction to Nuclear Engineering 3 - Continuation of NES 402. Study of shielding and radiation attenuation. Elementary reactor design based on the pressurized water concept. (4 q.h.)

NES 404 Nuclear Engineering Laboratory 1 - Study of experimental procedures used in reactor operation, personnel monitoring, radiation detection devices and statistics of nuclear counting systems. (4 q.h.)

NES 405 Thermodynamics, Heat and Mass Transfer in Nuclear Systems - Thermodynamic aspects of nuclear power, reactor heat generation and removal, and heat transfer and fluid flow. (4 q.h.)

NES 430 Applications of Nuclear Radiation and Energy 1 - Radioisotopes and ionizing radiation in solving engineering and research problems. Nuclear explosives for peaceful purposes are examined. (4 q.h.)

NES 431 Applications of Nuclear Radiation and Energy - Application of radioactive materials and ionizing radiation for measurements in chemistry, physics, engineering, geology, and astrophysics. (3 q.h.)

NES 432 Nuclear Processing and Separations - Chemical processing of fertile and fissile materials and irradiated fuels, changes in composition and reactivity during fuel irradiation, nuclear reactors and chemical plants associated with them, waste disposal. (4 q.h.)

NES 435 Interaction of Radiation with Matter - Processes by which radiation interacts with matter and applications in research, industry, and medicine. (4 q.h.)

NES 440 Nuclear Instrumentation Systems - Basic operational principles of radiation detection systems; counting circuitry and systems for radiation protection, nuclear reactor safety, and control. (4 q.h.)

NES 451 Nuclear Power Reactor Design - Design of major systems and components of several types of nuclear power reactors. (4 q.h.)

NES 470 Advanced Concepts for Nuclear Energy - Introduction to plasmas is given with emphasis on engineering applications. Areas covered are: thermonuclear fusion, lasers, gas discharges, arcs, MHD power generation, and thermionic energy conversion. (4 q.h.)

NES 496 Special Problems in Nuclear Engineering Sciences - Individually selected problems or projects in the student's major field of engineering study. May be repeated up to maximum of 12 credits. (1-6 q.h.)

NES 499 Coop Work Experiences Sciences - Practical engineering work under industrial supervision, as set forth in the College of Engineering Regulations. (1-5 q.h.)

INSTITUTION: UNIVERSITY OF FLORIDA

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Engineering Sciences

DEGREE: Master of Science (M.S.)
Master of Engineering (M.E.)
Engineer
Doctor of Philosophy (Ph.D.)

CONTACT: Dr. E. E. Carroll, Jr., Chairman
Department of Nuclear Engineering Sciences
University of Florida
Gainesville, Florida 32611
(904) 302-1401

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The graduate program in nuclear engineering was begun in 1958 for the primary purpose of scientific research. Shortly thereafter, in response to the need for qualified nuclear operators there was a shift in emphasis to instruction in applied technology. Currently, the student may elect a program in applied technology or one in research.

Each graduate of this department will likely have several offers for employment. Typical occupations which a degree in nuclear engineering leads to are as nuclear engineers, instructors, researchers, nuclear instrumentation design and manufacturing experts, and nuclear reactor operators. Architectural engineering firms, the military, public utilities, nuclear facilities, hospitals, and manufacturers all employ nuclear engineers.

Students have available to them, for classes and for research, a nuclear reactor facility which is composed of a 100 kw argonaut nuclear reactor; an IBM-2800 digital computer; two analog computers; a hybrid computer facility; a nuclear plasma and laser research facility; two whole body counters; a large close-to-critical, one-of-a-kind, sub-critical facility; and a large inventory of other specialized nuclear instrumentation.

The University of Florida is a member of Oak Ridge Associated Universities (ORAU) in Tennessee. ORAU provides additional support for this program by inviting students and faculty to make use of the training capabilities and national laboratory facility at Oak Ridge. University of Florida's faculty and students may either take courses or conduct research.

Upgrade and brush-up workshops are conducted regularly for nuclear reactor operators. High school teachers from all over Florida are invited to participate in week-long workshops which consider nuclear and alternative methods of energy production and storage. On campus a course entitled Nuclear Technology in Modern Life is offered as a non-major elective and has experienced growth in enrollment each time it is offered. The Department of Nuclear Engineering Sciences provides access to its facilities and advisory assistance to public facilities, colleges, and training centers.

PROGRAM REQUIREMENTS

All entrants are required by the Graduate School to have taken the Graduate Records Examination prior to making application, to have satisfactory undergraduate records, and letters of recommendation.

Students may pursue a Master of Science degree or a Master of Engineering degree, the distinction being that the M.E. degree is accredited by the Engineers' Council for Professional Development (ECPD) and requires an undergraduate degree from an ECPD accredited program or the equivalent for admission.

A background in mathematics and/or science is necessary in order to enter the M.S. program. Upon entrance, an admission evaluator reviews the academic background of each student, determines where course deficits may exist, and assists in making an appropriate plan of study for the student to follow.

With each of these degrees, it is possible to select either a thesis or non-thesis option. Any student desiring a Ph.D. degree should prepare a thesis. The thesis option requires a minimum of forty-five credits, nine of which may go to one's thesis and the remainder to course work. Under the non-thesis plan one must have forty-eight credits, six of which must go to the preparation and presentation of a special project.

The Engineer degree is designed for engineers who require additional depth in their educations. This degree requires forty-five credits beyond the level of the master's degree. Although this degree falls between the master's and the doctoral levels, it should not be considered partial fulfillment of the requirements for the Ph.D.; it, in itself is a clearly defined degree.

Admission to candidacy to the doctoral program is based on one's performance on a qualifying examination, written and oral, and upon the academic record of the student. The qualifying exam is given after all course work is completed. Students must have proficiency in one language other than English.

In each of the graduate programs, one may choose to concentrate his/her study in the area of nuclear power engineering, radiological sciences and engineering physics, or thermonuclear fusion. Specific areas of emphasis include advanced nuclear power concepts, nuclear reactor and power plant technology and operations, reactor dynamics and control, environmental aspects of nuclear power generation, neutron and reactor physics, nuclear plasma and laser technology, thermonuclear fusion systems, nuclear radiation chemistry, high-temperature materials, nuclear detection and instrumentation, bionucleonics, energy systems analysis, medical radiation physics, radiation biology and health physics.

CURRENT FACULTY, STUDENTS, GRADUATES

The faculty is composed of eleven full-time persons and one half-time split appointment with the Department of Physics. Faculty members divide their attention so as to allow 20-25 percent of their time for research and 75-80 percent of their time for teaching.

During the academic year 1977-1978 fifty-five people were enrolled in the master's and the doctoral programs full-time, and twenty were enrolled part-time. The number of master's degrees awarded has been increasing from fifteen in 1972 to twenty-four in 1976. There are usually one to three Ph.D.'s awarded each year. The last Engineer degree was given in 1974.

Nearly 80 percent of the graduate students are receiving financial assistance from a variety of sources: research contracts and grants; six to eight teaching assistantships; two to eight Department of Energy (formerly Energy Research and Development Administration) traineeships; National Science Foundation fellowships; Nuclear Regulatory Commission (formerly Atomic Energy Commission) fellowships; foreign governments; Veteran's Administration; Nuclear ROTC, and others.

More than half of the graduates utilize the Campus Placement Office when seeking employment, and with excellent success. Commonly, positions are described in publications such as Nuclear News. The Student American Nuclear Society is also a good source of employment leads. Faculty members are contacted regularly by potential employers looking for candidates to interview. One hundred percent of the graduates find employment in their field.

PROGRAM PROJECTIONS

The enrollment has nearly reached its ceiling respective of facility and faculty size. Development and expansion of a thermonuclear engineering program is currently under way.

ADDITIONAL INFORMATION

The American Nuclear Society has given the University of Florida's Chapter of its student society the Glasstone Award for excellence four of the past seven years (it may not be awarded to the same institution two years in a row).

The State University of New York (SUNY) - Buffalo's ranking of graduate engineering departments ranks the nuclear engineering graduate program at the University of Florida in the top twelve in the nation.

COURSE DESCRIPTION

ENU 5195 (NES 551) Nuclear Power Reactors I - Various types of nuclear reactors for power generation, design, construction, materials, heat transfer and cooling systems. (4 q.h.)

ENU 5186 (NES 555) Reactor Fuel Cycles - Fuel management problem in nuclear power reactors. Reactivity, breeding, fuel and fission product inventory as a function of life time; power distribution and fuel relocation. (3 q.h.)

ENU 5176 (NES 570) Principles of Nuclear Reactor Operations - Reactor start-up, reactor physics measurements and control calibrations, principles of control and operation and problems of power operation. (4 q.h.)

ENU 6106 (NES 610) Reactor Analysis I - Neutron diffusion theory. Homogeneous and one-velocity reactors. Time-dependent behavior of neutron flux. Reactor kinetics with temperature dependence. (3 q.h.)

ENU 6107 (NES 611) Reactor Analysis II - Reactor analysis in terms of the slowing-down model and Fermi-age theory. Six-factor formula, reactor temperature coefficients, introduction to perturbation theory as applied to reactivity calculations. (3 q.h.)

ENU 6108 (NES 612) Advanced Reactor Analysis - Analytical methods of heterogeneous reactor calculations, fundamentals of control-rod theory, disadvantage factor, thermal utilization, resonance escape probability, fast fission; monoenergetic transport theory. (3 q.h.)

ENU 6117 (NES 614) Neutron Transport Theory - Neutron transport equation, approximation based on orthogonal functions, variational techniques, and Monte Carlo methods applied to monoenergetic and energy-dependent transport theory. (3 q.h.)

ENU 6241 (NES 616) Numerical Methods of Reactor Analysis - Numerical solutions to reactor analysis problems. Solution of one-, two-, and three dimensional diffusion equations, multiregion and multigroup diffusion methods. P^n and S^n calculations. (4 q.h.)

ENU 6210 (NES 617) Computer Programs in the Nuclear Industry - Description and use of methods and codes used in reactor physics calculation in industry. (4 q.h.)

ENU 6167 (NES 618) Principles of Fast Reactors - Underlying mathematical techniques of fast reactor physics. Quantum mechanical procedures for nuclear processes involved in a fast reactor. Inelastic neutron scattering and resonance reactions. (3 q.h.)

ENU 6168 (NES 619) Fast Reactor Analysis - Computation of sodium void. Doppler and temperature coefficients. Fast reactor breeding ratio. Problems of fast reactor breeding. (3 q.h.)

ENU 6197 (NES 651) Nuclear Power Reactors II - Nuclear reactors for power generation. Emphasis on use of computer codes and advanced set of problems. (4 q.h.)

ENU 6147 (NES 652) Reactor Technology I - Theories of previous courses applied to analytical design and economics of an integrated fast reactor nuclear plant. (4 q.h.)

ENU 6148 (NES 653) Reactor Technology II - Analysis of reactor systems by comparison of actual and predicted performance. Emphasis on use of computer codes. (4 q.h.)

ENU 6636 (NES 655) Fundamental Aspects of Reactor Shielding - Shielding design fundamental. Methods of calculating gamma-ray attenuation, fast neutron penetration, effects of ducts and voids in shields, problems of heat generation and deposition in reactor components. (3 q.h.)

ENU 6126 (NES 660) Fundamentals of Reactor Kinetics - Dynamic behavior of nuclear reactor systems from the point of view of linear control theory. Laboratory use of analog computer to study reactor kinetics problems. (4 q.h.)

ENU 6127 (NES 661) Advanced Reactor Kinetics - Nuclear reactor dynamics; spatially dependent kinetics; techniques of nonlinear stability analysis; kinetics of various reactor prototypes. (3 q.h.)

ENU 6745 (NES 670) Plasma Spectroscopy - Spectroscopic techniques for measurement of temperature and density of plasma. Application to thermonuclear direct energy conversion devices. (4 q.h.)

ENU 6745 (NES 673) Advanced Plasma Theory - Fundamental equations of statistical plasma theory: Vlasov, Boltzmann, Fokker-Planck, and radiation transport equations, their solution, and typical application to plasmas. (4 q.h.)

ENU 6717 (NES 674) Thermonuclear Fusion - Foundations of thermonuclear reactions. Methods of heating plasmas to extreme temperatures; plasma containment by magnetic fields; plasma instabilities. (3 q.h.)

ENU 6707 (NES 678) Direct Energy Conversion - Direct conversion systems. Emphasis on system involving nuclear reactors or nuclear reactions. (4 q.h.)

INSTITUTION: UNIVERSITY OF KENTUCKY

PROGRAM: Energy (Coal) Engineering

DEPARTMENT: Chemical Engineering

DEGREE: Master of Science (M.S.)
Doctor of Philosophy (Ph.D.)

CONTACT: Dr. Robert Grieves, Chairman
Department of Chemical Engineering
University of Kentucky
Lexington, Kentucky 40506
(606) 257-1748

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Chemical Engineering began with the Bachelor of Science degree program in 1957. The M.S. followed in 1967, the same year the B.S. became accredited by the Engineers' Council for Professional Development; the Ph.D. began in 1969.

Students have several options for specialization; they man elect a conventional chemical engineering curriculum, one in energy engineering, or one in environmental engineering. The program in energy engineering emphasizes the production of synthetic fuels from coal.

Kentucky is the nation's leading coal producing state, and its government has made a substantial and continuing financial commitment to coal research and development. The University of Kentucky's Institute for Mining and Minerals Research (IMMR) is implementing the state's program in a recently completed five million dollar facility. IMMR provides unique opportunities for students conducting their thesis or dissertation projects. Additional support by way of course offerings comes from the Department of Mechanical Engineering in nuclear engineering, combustion, and direct energy conversion. Particular areas of this program which receive emphasis are chemical coal desulphurization, coal conversion processes, and thermochemical hydrogen production.

Graduates of the energy option are in demand by industry with capabilities and credentials as both energy engineers and as chemical engineers. Consulting firms, research institutes/centers, specialized equipment marketers all have need of the skills of this type of graduate. Graduates are in demand by the larger coal and oil companies which have research divisions. In federal, state and municipal government, they are skilled in communicating with the energy producing industries and in assisting them when changeovers to newer, more efficient production methods and fuel sources occur.

Approximately half of the space which the department occupies is devoted to experimental research. Analytical instruments such as IR (infra-red) and UV (ultra-violet) spectrophotometers, an automatic carbon analyzer, several gas chromatographs, a low temperature asher, surface area analyzer, and atomic absorption spectrophotometer are available and operated exclusively by the department. Other more sophisticated instruments are available upon request from other departments. The engineering library is located in the same building as the department and the computer center is adjacent to it. The Institute for Mining and Minerals Research is a unique supportive feature of this program providing a full range of research topics and complete access to the facility and its staff. Research opportunities are also provided by the Water Resources Research Institute.

PROGRAM REQUIREMENTS

Students who wish to enter the graduate program should have taken the Graduate Records Examination, have undergraduate degrees from appropriate ECPD accredited programs or the equivalent, have satisfactory academic records, and letters of recommendation.

The basic program consists of eight, three-semester-credit courses in addition to a suitable M.S. thesis on an energy related topic. For students with extensive experience in the energy field, the thesis may be waived and replaced with two additional courses. Considerable flexibility exists in the selection of courses and thesis topics.

In addition to the M.S. energy specialization, individualized programs may be designed for those wishing to pursue a Ph.D. degree with a concentration in energy engineering. In the past, eight Ph.D. degrees have been awarded (not only in the energy option).

The candidate for the Ph.D. is usually required to devote no fewer than three years (beyond the B.S. degree) of graduate study to the broad field of chemical engineering, present a satisfactory thesis, and pass a comprehensive examination on his/her thesis topic and chosen field. There is no stipulated number of courses which the Ph.D. student must complete, rather, an individualized program is designed by the student and his/her Thesis Advisory Committee. In order to insure scientific literacy, each student is required to pass a reading examination or special course in scientific French, German, or Russian.

CURRENT FACULTY, STUDENTS, GRADUATES

There are ten full-time faculty members in chemical engineering, six of whom are deeply involved in the field of energy. A breakdown of the faculty responsibilities shows 47 percent of their time devoted to teaching, 10 percent to administration, 10 percent to professional activities, and 33 percent to research. Faculty in the Department of Mechanical Engineering provide support by way of teaching required courses and approved electives.

In the fall of 1977 there were twenty full-time and five part-time graduate students in chemical engineering. Six of the full-time people chose the option in environmental engineering, five chose classical chemical engineering, and ten selected energy engineering. Each of the full-time students is receiving graduate fellowships with no teaching or research duties.

In 1977 there were slightly fewer M.S. graduates than in years past. The five year average prior to 1977 was thirteen and in 1977 there were nine (not exclusively energy engineering).

The campus placement service has been an effective agent in helping graduates find employment in chemical engineering, just as the professional contacts made by faculty members have been. A follow-up survey traced the employment history of each of the sixty-nine advanced degree graduates in chemical engineering. Thirty-six accepted positions with industry, twelve accepted government placements (three with the Federal EPA, one with TVA, and eight with state environmental protection agencies), six continued their educations, three accepted college or university teaching positions, two were employed with consulting firms, three with public utilities, and two with research institutes.

It is valuable for the graduate in some instances to become certified as a Professional Engineer. This registration is on a state by state basis, but the procedure is generally constant for each. Upon graduation a state board examination is conducted at which time those who have passed will receive a training engineering certificate. After five years of practice a Professional Engineer status is registered. Thirty to 40 percent of all chemical engineer graduates will take this examination.

PROGRAM PROJECTIONS

The increasing focus on energy technology and the volume of industrial interest in Kentucky's coal production cause this option to be popular among students. The program should continue to expand modestly.

COURSE DESCRIPTION

CME 505 Analysis of Chemical Engineering Problems - Application of numerical methods, differential equations, and transforms to complex chemical engineering problems. (3 s.h.)

CME 515 Air Pollution Control - Kinetics and equilibria of photochemical and "dark" atmospheric reactions. Atmospheric statics and dynamics including lapse rates, inversions, and vertical and horizontal air motion. Single and area source diffusion. Stack meteorology. (3 s.h.)

CME 530 Equilibrium Thermodynamics - Criteria for physical and chemical equilibria, including: predictive equations, solution theory, chemical activity, coupled chemical equilibria, and external constraints. Emphasis may be on vapor-liquid equilibrium, chemical reaction equilibrium, or complex ionic equilibria in dilute aqueous solutions and suspensions. (3 s.h.)

CME 555 Advanced Chemical Engineering Process Design I - Advanced chemical process and plant design providing conceptual details of project engineering methods. (3 s.h.)

CME 565 Energy Engineering - Energy supply and demand, material and energy balances for fossil fuel to fuel conversion including thermodynamic considerations, analysis of electrical power generation by conventional methods and by potential methods. (3 s.h.)

CME 615 Advanced Air Pollution Control - Principles and techniques of control of atmospheric pollution, including process design for the removal of gaseous and particulate pollutants from air streams. Legal and administrative aspects of control. (3 s.h.)

CME 633 Diffusional Mass Transfer Operations - Advanced course in diffusional processes depending upon current literature for much of its content. Multicomponent diffusional processes. Turbulent diffusion. Modeling of diffusion in biological systems. (3 s.h.)

CME 650 Advanced Chemical Reactor Design - Rate expressions for heterogeneous reaction kinetics; energy and mass transport within and external to reacting porous catalysts; design equations for fixed-moving and fluidized-bed reactors. (3 s.h.)

CME 665 Equilibrium and Rate Processes of Coal Conversion - Fundamentals of coal gasification and liquefaction processes including thermodynamic, chemical kinetic, and physical rate processes considerations, multiphase flow, fluidization, and integrated processes. (3 s.h.)

ME 475 Introduction to Nuclear Engineering - Introduction to basic topics of nuclear science. Interaction of radiation with matter. Design and operation of nuclear reactors, shielding. Instrumentation, health physics, fuel cycles, use of radiosotopes. (3 s.h.)

ME 514 Nuclear Ractor Analysis I - Neutron cross-sections, fission process. Infinite medium criticality calculations, four factor formula. Neutron diffusion and slowing down theory. Age theory, criticality calculations for the homogeneous reactor, elementary reactor kinetics. Reflected reactors multigroup methods. Control rod theory, heterogeneous reactors. (3 s.h.)

ME 515 Fuel Management and Economics of Nuclear Reactors - Nuclear fuels, fuel element claddings, burnup, fission products and waste handling, processing and recycling of fissile materials, isotope separation, and applications. Fuel cycle performance of typical reactors. Uranium resources and cost, nuclear plant costs and interrelation between conventional and nuclear power costs. (3 s.h.)

ME 556 Direct Energy Conversión Processes - Basic considerations of direct conversion of thermal to electrical energy. Thermodynamic and performance characteristics of solid state conversion devices including thermoelectric, thermoionic and photovoltaic systems. Fuel cells; MHD. (3 s.h.)

ME 611 Nuclear Reactor Analysis II - Advanced topics in reactor analysis. Boltzman equation, spherical harmonic methods and other approximate solutions of the Boltzman equation. Perturbation theory, neutron importance. Introduction to neutron thermalization. (3 s.h.)

INSTITUTION: UNIVERSITY OF NEW MEXICO

PROGRAM: Nuclear Engineering

DEPARTMENT: Chemical and Nuclear Engineering

DEGREE: Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) in Nuclear Engineering

CONTACT: Dr. Robert L. Long
Chairperson, Chemical and Nuclear Engineering
University of New Mexico
Albuquerque, New Mexico 87131
(505) 277-5431

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The graduate nuclear engineering program was established on the main University of New Mexico campus in Albuquerque in 1964. This graduate program, however, has been in existence since 1958. Between the years 1958 and 1964, the program was conducted through UNM at the Los Alamos Scientific Laboratory. Today, the university continues to operate a graduate program at Los Alamos open to members of the staff who wish to pursue advanced degrees.

The UNM graduate programs in nuclear engineering place a strong emphasis on integration of the areas of chemical and nuclear engineering. Faculty members believe this combination of academic concentrations equips the student for entrance into the world of work with the highest caliber educational background.

The College of Engineering has up-to-date, well equiped nuclear engineering laboratories, on the campus. Students, at UNM, also utilize the Sandia Laboratory and Los Alamos Scientific Laboratory advanced reactors and radiation equipment for research as well as for instruction.

Graduates of this nuclear engineering program are highly employable. They face few, if any, obstacles to obtaining challenging jobs, for example: the nuclear power industries; and Sandia, Los Alamos and the military weapons laboratories. Graduates enter occupations including: nuclear engineer; environmental physicist; radiation engineer; and, the Nuclear Regulatory Commission's inspection, review and standards work. At the masters level at least 15% of the students continue their educational work in pursuit of the doctoral degree.

PROGRAM REQUIREMENTS

Admission to the nuclear engineering graduate programs requires acceptance by the Graduate School and by the College of Engineering. Candidates are selected by the college through a screening committee established to review the student's academic qualifications and background.

Those students who are accepted into the nuclear engineering graduate program at the masters level have accomplished concentrated undergraduate work in mathematics, physics and nuclear engineering. Students must also demonstrate a high degree of competence in another branch of engineering or in science.

The programs at the masters level includes extensive study in the areas of radiation transport, interaction, detection, and effects; and, plasma physics and controlled fusion. The requirements may be completed through one of the following plans:

Requirements*	Plan I	Plan II
Minimum hrs. course work	24	30
Minimum hrs. 500-level courses	6	12
Hrs. in residence	18	26
Hrs. thesis credit	6	0
Hrs. problems/workshop	6/5	12/0
Major hrs.	21	20
Masters Examination	yes	yes

*Refers to semester hours. No minor.

In order for a student to be admitted to the doctoral program, competency in the basic areas of nuclear engineering must be demonstrated by means of satisfactory completion of the departmental qualifying examination.

The requirements for the doctorate include at least three years of intensive study and research beyond the bachelor's degree. Course work and residency requirements are specified by the Graduate School, the department and a doctoral committee.

CURRENT FACULTY, STUDENTS, GRADUATES

The current chemical and nuclear engineering faculty includes ten full-time professors, and two full-time visiting professors (one from Japan and one from Taiwan). All faculty members have doctoral degrees in appropriate academic areas and have conducted recognized research in the field.

At present the student enrollment totals 46 male graduate students. The masters program includes 10 full-time and 11 part-time students. The doctoral program is composed of 10 full-time and 15 part-time students.

Over the last three years, a per annum of 12 students earned the Master of Science degree, and three students annually have been awarded the Doctor of Philosophy degree.

PROGRAM PROJECTIONS

Although the program faculty and students have stabilized, some future expansion is anticipated in response to an increasing emphasis on the needs for increased domestic energy sources. This expansion is anticipated even in light of the current controversial nature of the nuclear energy field.

To meet the needs of an increase in students and research activities, an addition of three faculty members is anticipated by 1979 These new persons will probably include one chemical engineer, one nuclear engineer, an one person with expertise in disposal of radiation wastes.

COURSE DESCRIPTION

NE 420 Fundamentals of Nuclear Engineering - Radioactivity, nuclear reactions and cross-sections, conservation laws, elementary particles and particle distributions, neutron physics, and electromagnetic radiation. (3 s.h.)

NE 423L Radiation Measurements and Analysis - The detection and analysis of charged particles, neutrons, and electromagnetic radiation. Experiments to demonstrate the properties of radiation, radioactive decay, cross-sections, detection, counting statistics, energy distributions, scattering, absorption, activation and safety monitoring. (1-3 s.h.)

NE 430 Introduction to Nuclear Engineering - Principally for non-nuclear engineering majors. The nucleus and nuclear properties; fission process and chain reaction; survey of design and operation of reactors and associated equipment; effects, uses, and detection of radiation. (3 s.h.)

NE 461 Power Reactor Technology - Technology of nuclear reactor systems. Emphasis on nuclear fuel cycle, system design interactions, and reactor thermalhydraulic analysis. (3 s.h.)

NE 465 Nuclear Power Systems - Seminar on nuclear power systems with emphasis on independent study; safety analysis reports for light water, gas-cooled, and liquid metal fast breeder reactors; environmental impact statements; student selected topics. (3 s.h.)

NE 466 Nuclear Environmental Safety Analysis - Radiation protection and safety; contributors to radiation environment; environmental monitoring; radioactive waste handling and disposal; guidelines, standard, and regulations; and the environmental impact statement. (3 s.h.)

NE 470 Materials for Energy Production - (Also offered as ChE 470.) Fundamentals of materials selection and development for energy production in chemical, nuclear, geothermal, and solar systems. (3 s.h.)

NE 476 Reactor Fuel Processing - Fuel cycles in nuclear reactors; production of reactor fuels; processing of spent fuels by precipitation, solvent extraction, etc.; and separation of isotopes. (3 s.h.)

NE 480 Introduction to Controlled Fusion - Basic theory of plasmas: orbit theory, magnetohydrodynamics, and transport phenomena. Science and technology of controlled fusion systems; conditions for thermonuclear reactions, formation and heating, containment, and characteristics of existing fusion systems. (3 s.h.)

NE 485 Controlled Thermonuclear Reactor Technology - Introduction to controlled thermonuclear reactor (CTR) technology. (1) Systems: characteristics of proposed CTR systems; (2) system design: materials, scaling laws, plant cycle, economics, safety, shielding, blanket, magnets; (3) operation: startup, operating mode, burnup, tritium cycle, control. Prerequisite: 420 or equivalent. (3 s.h.)

NE 510-511 Nuclear Reactor Theory I & II - The theory of nuclear chain-reacting systems with emphasis on computer methods used in current applications. NE 510 considers nuclear reaction rates, one-speed diffusion theory, and reactor kinetics. NE 511 considers multi-group diffusion theory, transport theory and Monte Carlo methods, and applications to nuclear system design. (3,3 s.h.)

NE 513-514L Nuclear Engineering Laboratory I & II - Laboratory investigations of the theory and practice of nuclear chain reacting systems. NE 513L includes experiments on the department's AGN-201M reactor, the ACPR and SPR reactors at Sandia Laboratories and the Jezebel reactor at the Los Alamos Scientific Laboratory. In NE 514L, students design and perform experiments in their own special interest areas. (1-3, 1-3 s.h.)

NE 515 Seminar - A selected topic of current interest in nuclear science and engineering. (1-3 s.h.)

NE 520 Interaction of Radiation and Matter - The theory and practice relating to interaction of radiation with matter. Emphasis given to biological effects and to radiation damage effects on reactor structural materials and systems. (3 s.h.)

NE 551-552 Problems - Consideration of a special problem selected by a student and the supervising faculty member for topics outside of the scope of current course offerings. (1-3 s.h. each semester)

NE 560 Reactor Kinetics and Control - Theory of the kinetic behavior of a nuclear reactor system with emphasis on control and dynamic behavior. (3 s.h.)

NE 570 Materials for Nuclear Applications - Fundamentals of materials selection and development for nuclear systems. Topics: metallic and ceramic fuels, structural materials, coolants, thermal effects, radiation damage mechanisms and effects, and current problem areas. (3 s.h.)

NE 580 Plasma Science and Technology - Advanced theory and technology of plasma systems for applications to controlled thermonuclear fusion. (3 s.h.)

INSTITUTION: UNIVERSITY OF PENNSYLVANIA

PROGRAM: Energy Engineering

DEPARTMENT: Interdisciplinary Program within the College of Engineering and Applied Science

DEGREE: Master of Science in Engineering (Energy Engineering)

CONTACT: Dr. Lawrence Eisenberg, Chairman
Graduate Group Committee on Energy Engineering
The Energy Center
3221 Walnut Street / K2
University of Pennsylvania
Philadelphia, Pennsylvania 19174
(215) 243-8507

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The College of Engineering and Applied Science at the University of Pennsylvania intends for the interdisciplinary Energy Engineering program to be a professional degree program that will provide the concentrated study necessary for students pursuing energy-related careers. They receive graduate instruction in one of the diverse areas associated with the science and technology of production, distribution, and utilization of conventional and non-conventional forms of energy.

Opportunities for specialization in one of several areas within the Energy Engineering program include four: Energy Systems; Solar Energy; Energy Conversion; and Resource and Environmental Systems. Participants in this graduate professional program have available the full resources of the College and the University community in designing their particular program of the study.

PROGRAM REQUIREMENTS

Applicants with baccalaureate degrees in one of the traditional engineering disciplines are considered for admission. Candidates should also furnish two letters of reference from persons acquainted with their technical ability. At least one of these should be connected with the institution from which the transcript is submitted.

The Master of Science in Engineering program can include either a minimum of 10 courses (no thesis required) or a minimum of 6 courses and a thesis. Upon entering the program, students are required to take a series of core courses: Classical Thermodynamics to Energy Engineering; Engineering Mathematics; Engineering Mathematics; Engineering Materials; and Energy Conversion. In addition, one course must be selected from the following list: Process Dynamics and Control; Transport Processes; Power Transmission and Distribution; Nuclear Engineering; and Advanced Heat Transfer. Remaining course work and the thesis may be taken in any department of the College of Engineering and Applied Science and should focus on a particular area of emphasis.

A limited number of scholarships, fellowships, teaching, and research assistantships are available to students in the Energy Engineering program.

CURRENT FACULTY, STUDENTS, GRADUATES

The Graduate Group on Energy Engineering is the official faculty of the program and is composed of faculty members from the various engineering departments within the College of Engineering and Applied Science. The Graduate Group is comprised of both research and teaching faculty and none have strictly research functions. There are sixteen faculty members comprising the Graduate Group on Energy Engineering staff. Faculty of various departments within the College of Engineering and Applied Science work on a variety of energy-related research programs.

A total of eight students (no females) are enrolled in the Energy Engineering program at the present time (Spring, 1978). Eighty percent of these students (6) are part-time. The Energy Engineering program is samll and enrollment has not increased in recent years and is not expected to increase significantly in the next few years. It is estimated that only one student on the average (over three years) completes the M.S. in Engineering degree annually.

Virtually all graduates obtain employment directly in their field of study. It is estimated that about one-half find positions in industry and that the other one-half find government positions with state or federal regualtory agencies (e.g. Department of Energy).

PROGRAM PROJECTIONS

University officials project that the energy field will continue to increase in importance and that qualified energy engineering graduates will be needed to perform critical roles. Increased emphasis will be also placed on the environmental aspects associated with energy production and conversion. A definite shift to more of an energy orientation in academia is detected among program officials in the foreseeable future.

The Energy Engineering program is not expected to increase in size significantly because it is a small program which responds to specialized needs of an interdisciplinary basis. Enrollment is expected to remain stable for the next few years.

COURSE DESCRIPTION

(the following is a partial listing of courses)

Core Course Descriptions

Classical Thermodynamics or Applications of Thermodynamics to Energy Engineering

CHE 618 Applications of Thermodynamics to Chemical Engineering - Review of classical thermodynamics. Phase and chemical equilibria for multicomponent systems.

MEAM 561 Engineering Thermodynamics - Advanced classical equilibrium thermodynamics and fundamentals of nonequilibrium thermodynamics.

Engineering Mathematics

SE 643 Engineering Mathematics II - Solution to linear ordinary differential equations by infinite series; properties of special functions; numerical integration and difference equations.

CHE/MEAM 501 Engineering Mathematics II - Ordinary differential equations; the Sturm-Liouville problem; and other topics.

Engineering Materials

MMS 555 Engineering Materials - Principles of the relationship between the structure and properties of materials used in the production, distribution, transformation, and storage of energy.

Energy Conversion

SE 566 Energy Generation and Conversion - Introductory course, topics to be covered include selections from energy conversion, direct energy conversion, mechanical and electrical energy conversion, energy transmission and storage.

Process Dynamics and Control

SE 535 Introduction to Feedback Control Systems - Feedback theory, transfer functions, linear stability criteria.

CHE 647 Process Dynamics and Automatic Control - Principles of automatic process control; controller actions, detection of period signals in noise, distributed and lumped parameter processes.

Transport Processes

CHE 640 Transport Processes I - Analysis of momentum and heat transfer starting from the equations for the conversion of mass, momentum and energy.

Power Transmission and Distribution

SE 664 Transmission Lines and Networks - Electrical power transmission systems, parameters; performance under abnormal conditions, short-circuits, over-voltages, and power swings; power system protection, performance of relays and circuit breeders; introduction to high voltage d-c transmission systems.

Nuclear Engineering

MEAM 682 Introduction to Nuclear Power Engineering I - Topics including reactor theory; nuclear reactions; fission, diffusion and slow-down of neutrons, reactor analysis, fast neutrons and the breeder reactor, kinetics and control.

Advanced Heat Transfer

CHE 630 Seminar In Heat Transfer - Lectures, study of classical and current literature, and individual research.

MEAM 664 Advanced Heat Transfer: Conduction and Radiation - The energy equation and its boundary conditions; solution by exact and approximate analytical techniques, by numerical methods and by analogues in various spatial domains. Radiation.

MEAM 665 Advanced Heat Transfer: Convection - Fundamental equations, laminar and turbulent forced convection on external surfaces, and inside tubes and ducts, forced convection with mass transfer, free convection, combined free and forced convection, condensation, boiling, analysis of heat exchangers.

INSTITUTION: UNIVERSITY OF PENNSYLVANIA

PROGRAM: Energy Management and Policy

DEPARTMENT: Graduate Group in Energy Management and Policy

DEGREE: Master of Science in Energy Management and Policy
Doctor of Philosophy in Energy Management and Policy

CONTACT: Dr. Lawrence Eisenberg, Chairman
Graduate Group in Energy Management and Policy
The University of Pennsylvania Energy Center
3221 Walnut St./K2
Philadelphia, Pennsylvania 19104
(215) 243-8507

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The graduate program in Energy Management and Policy, started in 1971, is a multidisciplinary problem-solving curriculum oriented toward the identification and solution of energy-related problems. Because energy management problems are scientific, managerial, environmental, social, and economic, the graduate program was established to prepare students to effectively utilize information from overlapping areas in various disciplines. The professional schools of Engineering, Law, Administration and Policy, City Planning, and Environmental Studies participate in the program. Students are expected to undergo advanced education in one of the relevant disciplines and to view the total program with a broad perspective.

Graduates are prepared to enter positions in state and federal energy agencies, in industry and in academia. Recent graduates have obtained positions in the U.S. Department of Energy, the MITRE corporation, state energy agencies, consulting firms, electric utilities, the Stanford Research Institute, and the Electric Power Research Institute. As energy systems analysts they have conducted computer modelling simulations and they have also found positions as energy economists.

The program's students utilize facilities of the Energy Center which include fully instrumented laboratories: Thermal energy storage laboratory; solar cell laboratory; experimental solar collector test apparatus; and an AC/DC systems simulation laboratory. Additional University facilities are utilized by the program including the School of Engineering's laboratories. One of the most important of the facilities is the University's computer installation which centers around the IBS 370 system. A number of computer programs for predicting the performance of solar collectors, solar heating systems, latent heat storage devices, and off-peak air conditioning systems incorporating thermal energy storage have been developed.

A major strong point of the Energy Center's Research has been the development of collaborative research programs with industry researchers. The program's students are thus provided with practical training by combining academic research with industrial research. The joint use of facilities and exchange of personnel are involved in this collaborative program.

PROGRAM REQUIREMENTS

In order to enter the Energy Management and Policy program, applicants are considered with baccalaureate degrees in the physical, natural and social sciences, mathematics and engineering. The Graduate Group of Energy Management and Policy requires prerequisites which include: 1 year of physical or life sciences, 1 year of basic calculus, and one year of social sciences. It is recommended that prospective applicants take the verbal and quantitative portions of the Graduate Record Examination, Aptitude Test.

Upon admission into the program, the student is assigned an Advisory Committee which serves to guide the student to an approved course of study and to periodically review the student's progress.

The M.S. degree in Energy Management and Policy is awarded upon completion of a minimum of 10 graduate course units, including a thesis. Five of the 10 course units are required to be in the Energy Management and Policy series and the remaining courses are normally selected from other University disciplines.

The Ph.D. degree is awarded upon completion of a minimum of 21 approved graduate course units. Students must pass a preliminary examination, a preliminary dissertation examination, and complete a dissertation. A student with an M.S. or M.A. degree may be credited up to 8 course units toward the Ph.D. degree.

Students in the graduate degree programs are encouraged to participate in the Energy Center's internship program where students are involved in energy planning, policy-making, and analysis activities in industry, consulting firms and governmental agencies. During the summer of 1978, internships are available at the Argonne National Laboratory, the Governor's Energy Council, and the City of Philadelphia.

Scholarships, teaching and research assistantships, and fellowships are available to assist qualified students in both the master's and doctoral programs.

CURRENT FACULTY, STUDENTS, GRADUATES

The Energy Center Research and Education program utilizes three different categories of professional personnel. A total of 35 staff and faculty members make up the primary faculty, the professional (non-academic) staff, and the adjunct faculty. The sixteen members of the Graduate Group are the official (primary faculty) of the Energy Center and the Energy Management and Policy Program. Four professional (non-academic) staff members work on the Center's research program. Fifteen adjunct faculty members are contributing faculty and are drawn from the disciplinary faculties of the University. The adjunct faculty contribute to the work of the Center as specific projects relating to their areas of expertise are undertaken.

The Energy Center has developed several research projects which impact upon environmental areas. The Center developed an electric energy management system to enable electric utilities to use relatively high sulfur coal and incorporate a structured mechanism for monitoring and managing the air qulaity impact of electric power production. Another example of the Center's activities was a project on technology for the conversion of solar energy to fuel gas.

There are currently 45 students enrolled in the Energy Management and Policy Program. Approximately 35 percent (16) are part-time and 20 percent (9) are female. An annual average of five M.S. degrees and two Ph.D.s are granted by the Graduate Group. Enrollment is rapidly increasing.

It is estimated that virtually all graduates obtain employment in their field and have experienced little difficulty in obtaining employment in their areas of interest. About 50 percent find private sector jobs and the other 50 percent obtain government positions.

PROGRAM PROJECTIONS

Although enrollment in the Energy Management and Policy Program is rapidly increasing, no new faculty members are anticipated to be recruited to offer additional courses in any of the participating departments because of financial constraints. Any important activity in the energy field can be supported by the present staffing structure. Program officials detect a shift in national emphasis from an environmental orientation in programs to more of an energy orientation and they are trying to respond to that shift.

COURSE DESCRIPTION

(the following is a partial listing of courses)

600 Energy Resources and Technology - The availability and utilization of present and future energy resources are covered. Their current and potential use in relation to technological feasibility is stressed. Basic concepts of technological efficiency are included, with emphasis upon current practices, future potential, and ultimate limitations.

601 Environmental Aspects of Energy Management - The role of environmental considerations in the management of energy resources is covered. Emphasis is placed upon environmental problems associated with the extraction of fuels and with energy conversions. A case study approach is used as a vehicle for investigating the trade-offs encountered in energy management.

602 Applications of Energy Management to Systems - An in-depth application of energy management concepts to large scale systems is covered. The relationships of energy source, conversion, utilization, economic and environmental trade-offs, and societal implications of a realistic energy system are treated.

605 Social Aspects of Energy Management - Methodological considerations in the study of the interrelationships between the social and cultural order and the natural and built environmental with particular attention to problems of energy, and other topics.

610 Economic and Financial Aspects of Energy Management - This course emphasizes a price-theoretic framework for policy development from an energy economics viewpoint.

620 Problem Solving Methodology - Energy problems are selected and formulated, well-defined goals adopted, and alternative solutions sought utilizing the concepts of input-output analysis, technology impact analysis, and operations research.

641 Simulation of Energy Systems - Simulation models of energy systems are developed.

699 Independent Study and Research - Prerequisite: Instructor's consent and approval of Chairman. Advanced study and research leading to completion of the student's research project or independent study.

INSTITUTION: UNIVERSITY OF TENNESSEE

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Engineering

DEGREE: Bachelor of Science (B.S.)

CONTACT: Dr. P. F. Pasqua, Head
Department of Nuclear Engineering
University of Tennessee
Knoxville, Tennessee 37916
(615) 974-2525

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

As a response to the rapidly increasing demand for engineers with a knowledge of nuclear phenomena, nuclear engineering became a department in 1957. Graduates of the baccalaureate program are equipped for entry into a variety of work in industry, research, or for graduate studies.

The department is housed in the Nuclear Engineering Building, which contains laboratories and equipment for monitoring, counting, and investigating various nuclear phenomena; it also contains subcritical reactors. Nuclear engineering has an arrangement with the Oak Ridge National Laboratory (ORNL) which permits students to utilize the facilities there for instruction and research. Included are the reactor facilities, the Information Centers, the libraries and depositories, and the computers. UT is a member of the Oak Ridge Associated Universities (ORAU) which provides students with additional opportunities for instruction and research.

PROGRAM REQUIREMENTS

University admissions standards require entrants to have completed an academic high school program and to submit their scores received on the ACT examination. Applicants must also have recommendations from their high school principals. In order to receive a bachelor's degree after July 1, 1978, all students must have completed one year of American history at the high school level or nine quarter hours of collegiate American history, as required by the General Assembly of the State of Tennessee. The College of Engineering further requires freshman entrants to have completed three years of English, two years of algebra, one year of geometry, and one-half year of advanced math or trigonometry. Three years of science, including physics are recommended.

The curriculum in nuclear engineering is designed to provide basic training in many of the fields encountered in the applications of nuclear and radioactive materials. The first two years are concerned with the fundamental courses in engineering, physics, mathematics, chemistry, and English. The final two years encompass scientific and engineering courses.

Nuclear engineering major requirements include the following courses: 2310-20-30 - Seminar, 3030 - Introduction to Reactor Analysis, 3040 - Environmental Effects of Nuclear Technology, 3150 - Dynamics and Controls, 3210-20 - Thermodynamics, 3730 - Momentum Transport, 4110-20-30 - Introduction to Nuclear Reactor Theory, 4210-20-30 - Nuclear Engineering Laboratory, 4710 - Energy Transport, 4720 - Reactor Thermal Design, 4730 - Nuclear Reactor Design, 4810 - Radiation Shielding, and 4820 - Reactor Kinetics and Controls. The entire program consists of the completion of one hundred and ninety-five quarter credits.

CURRENT FACULTY, STUDENTS, GRADUATES

The Department of Nuclear Engineering has nine full-time persons on its faculty, all of whom are involved in research to varying degrees.

There are one hundred and twenty-one students involved full-time in nuclear engineering, and nine part-time. An important feature of this department is its coop program. Neither seniors nor freshmen may participate in the coop, but of the remaining fifty-eight students, twenty-nine (half) have coop placements. No academic credit is received, and they must maintain a 3.0 average in their course work.

Twenty-three people are expected to graduate in the spring of 1978, and of those approximately fourteen, or 60 percent, will continue their studies in graduate school. The remainder are commonly employed by the Tennessee Valley Authority and various nuclear power plants. In years past, the Oak Ridge National Laboratory hired many of the UT graduates but it is feared that the nuclear facility may become "inbred" if graduates of other schools (and differing emphases) are not employed to a larger degree.

PROGRAM PROJECTIONS

Because of the tremendous need for new energy technologies, there are plans underway to develop an option for specialization in nuclear fusion. Also, the rightful concern over nuclear waste storage and ultimate disposal has caused this department to address that problem; a fuel management and waste disposal program is being designed.

COURSE DESCRIPTION

Required Courses:

2310-20-30 Seminar - Presentation and discussion of topics related to Nuclear Engineering. (1 q.h. each)

3030 Introduction to Reactor Analysis - Nuclear reactions and radiations, cross section, fission process, diffusion and slowing down, steady state reactor theory criticality condition, reflected reactors. (3 q.h.)

3040 Environmental Effects of Nuclear Technology - Study of effects on environment since advent of peaceful and military uses of nuclear energy. (3 q.h.)

3150 Dynamics and Controls - Systems differential equations; solution by classical methods; Laplace transform method; frequency response, stability, and control. (3 q.h.)

3210-20 Thermodynamics - Properties and laws of thermodynamic systems. First and second laws used to analyze power plant systems - both fossil fuel and fission. (4 q.h. each)

3730 Momentum Transport - Development of differential and integral momentum equations; elementary theory of turbulence, applications to piping systems, pumps and nuclear reactors. (4 q.h.)

4110-20-30 Introduction to Nuclear Reactor Theory - Nuclear structure; radioactive decay laws; neutron interaction; fission processes, chain-reacting systems; diffusion equation including multigroup diffusion theory, neutron moderation; reactivity coefficients; perturbation theory. (3 q.h. each)

4210-20-30 Nuclear Engineering Laboratory - Radiation detection and counting instrumentation, counting statistics, half-life and decay schemes, gamma spectrometry, cross-section measurements, analog computation, diffusion properties of neutrons, critical loading experiments, control rod calibration, statistical weight, shielding, xenon poisoning, prompt critical reactor behavior, fission density and adjoint flux. (3 q.h. each)

4710 Energy Transport - Development of differential and integral energy conservation equations; conduction, convection, and radiation heat transfer; application of nuclear reactor fuel elements and heat exchangers. (3 q.h.)

4720 Reactor Thermal Design - Hydrodynamics and heat transfer in boiling systems; boiling crises; fuel element thermal design, steam generator design. (3 q.h.)

4730 Nuclear Reactor Design - First order reactor design, integration with nonnuclear heat transfer and power conversion

4730 (Cont'd) - system, economic evaluation; optimization procedures, description of typical systems. (3 q.h.)

4810 Radiation Shielding - Types of radiation sources, gamma ray and neutron attenuation, biological effects of radiation, shield design. (3 q.h.)

4820 Reactor Kinetics and Controls - Derivation of kinetic equations; basic kinetics parameters; transient response with feedback; control and protective systems. (3 q.h.)

Electives:

4140 Thermonuclear Systems - Fusion reactions; properties of plasmas; plasma containment; plasma diagnostics; thermonuclear devices. (3 q.h.)

4530 Reactor Simulation Laboratory - Simulation of reactor design and operation with analog computer; reactor kinetics; single and multigroup theory, reactivity coefficients, poisoning, control rod calibration; power reactor; subcritical assembly. (3 q.h.)

4610-20-30 Reactor Power Systems - Nuclear structure, decay laws, neutron diffusion, time behavior of reactors, heat removal, analysis of reactor power plants; economic, safety, and environmental aspects of nuclear power. (3 q.h. each)

4840 Nuclear Reactor Safety - Presentation of reactor safety concepts and criteria; credible accidents; fission product release and transport; containment systems; accident analysis; engineered safeguards. (3 q.h.)

4930 Nuclear Fuel Management - Discussion of problems associated with processing of nuclear materials; fuel cycle analysis; burnup calculation. (3 q.h.)

INSTITUTION: UNIVERSITY OF TENNESSEE

PROGRAM: Nuclear Engineering

DEPARTMENT: Nuclear Engineering

DEGREE: Master of Engineering (M.E.)
Master of Science (M.S.)
Doctor of Philosophy (Ph.D.)

CONTACT: Dr. P. F. Pasqua, Head
Department of Nuclear Engineering
University of Tennessee
Knoxville, Tennessee 37916
(615) 974-2525

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

Nuclear engineering became a department in 1957 in response to the growing demand for engineers with expertise in the area of nuclear phenomena. Since its inception, the department has grown substantially and now offers a Bachelor of Science degree and three advanced degrees.

The Nuclear Engineering Building houses the department, and its teaching and research facilities. There exists, available for student use, equipment for monitoring, counting, and investigating various nuclear behaviors, as well as subcritical reactors. UT has several designated research contracts with the Oak Ridge National Laboratory (ORNL) which provides graduate students and faculty with unique research opportunities. Students are permitted to consider their time spent at ORNL toward their twenty hour/week requirement for research assistantship funding. With the exception of a few foreign students, nearly all of the graduate students are receiving financial assistance. Three people have teaching assistantships, with no actual teaching responsibilities; rather, they assist the professors. The remainder of the students have research assistantships. During 1976-1977, approximately one half million dollars composed the research budget, and the largest portion of that supported graduate students.

PROGRAM REQUIREMENTS

Admission to the Master of Engineering program requires the applicant to have an undergraduate degree in nuclear engineering, or the close equivalent of one, as stipulated by Engineers' Council for Professional Development accreditation requirements. This degree requires the completion of thirty-six quarter hours of course work, eighteen of which must be in nuclear engineering. A minimum of nine hours of design project, thesis, or twenty-four hours of Nuclear Engineering Practice (5980) must be completed. Documentary proof of significant engineering experience may be submitted in lieu of the design project, the thesis, or the practice, but in that case a total of forty-five hours of course work are required. Students must take nine quarter credits of work outside of the department. A minimum of one-third of the program must be in engineering design, and one-third of, or a combination of, advanced mathematics, computer sciences, basic sciences, or engineering sciences. A final oral examination on all work presented for a degree must be passed. This degree has been offered for the past two years.

Students from other disciplines of engineering and physics are welcome in this department. It is the feeling of a program source that these students enrich the entire department's log of information with their varied backgrounds. These students must take articulation work in nuclear engineering areas in which they are felt to be deficient enough to prevent them from enrolling in courses that they need. Two plans are available for students to choose from. The first requires forty-five credits of advisory committee approved courses. This program includes eighteen quarter hours in nuclear engineering, a minor of nine hours in mathematics, and a master's thesis. At the completion of the thesis and all graduate course work, a final examination must be passed.

An alternate program is available for M.S. students which involves engineering practice rather than a thesis. Those who elect this plan must complete thirty-six quarter hours of work, similar to the first M.S. plan. In addition, they must complete twenty-four quarter hours of Nuclear Engineering Practice (5980). Usually, the student registers for six hours of 5980 each quarter and investigates problems assigned by a member of the faculty. At the end of each quarter the student must submit a written report and make an oral presentation of the work. Upon completion of the program the student must pass a comprehensive examination over his/her program.

Students in the field of nuclear engineering desiring to study for the degree of Doctor of Philosophy must have a Bachelor of Science or a Master of Science degree from a recognized university with a major in engineering or physics, and present at least a B average. All candidates will be required to demonstrate general competence in the preliminary examination in the areas of engineering science, mathematics, and physics. At the same time all candidates will be required to demonstrate special competence in nuclear design.

Specific requirements for the Ph.D. in nuclear engineering include: a minimum of seventy-two quarter hours of credit beyond the bachelor's degree, exclusive of credit for the M.S. thesis or Nuclear Engineering Practice; a minimum of thirty-six credits in doctoral research; a minimum of forty-five hours in courses numbered 5000 (i.e., graduate level) or above, with at least twelve credits of 6000 level courses (exclusive of thesis or dissertation credit);

a minimum of eighteen quarter hours in mathematics or computer science in courses beyond nuclear engineering baccalaureate requirements (must be 4000 level or above); a minimum of nine quarter hours in courses numbered 5000 or above from a department other than nuclear engineering; and a reading knowledge of one foreign language will be determined by the student's doctoral committee.

CURRENT FACULTY, STUDENTS, GRADUATES

The faculty of the Department of Nuclear Engineering is composed of nine full-time persons, all of whom divide their attentions between teaching and research to varying degrees. Fifty graduate students are enrolled in this department, the largest portion of whom are pursuing the M.S. degree. This year it is expected that eight master's degrees and five Ph.D.'s will be awarded.

A follow-up survey showed that of twenty-two Ph.D. graduates, fifteen are employed in the state, and of the twenty-eight master's degrees awarded, fifteen are working in Tennessee. Twenty of these people are working at ORNL, and four are with the Tennessee Valley Authority (TVA). Now most graduates are looking to the private sector for employment, and with excellent success.

PROGRAM PROJECTIONS

Acknowledging our nation's critical need for the development of new energy sources and technologies, there is currently being planned an option in nuclear fusion technology. Also, a fuel management and waste disposal program is being designed to meet the need for engineers with expertise in the area of nuclear waste storage and ultimate disposal.

COURSE DESCRIPTION

5002 Non-Thesis Graduation Completion - Required for the non-thesis student not otherwise registered during any quarter when such a student uses university facilities and/or faculty time before degree is completed. (3 q.h.)

5110-20-30 Transport Processes in Nuclear Engineering - Momentum and heat transport; development of conservation equations: elementary theory of turbulence; heat transfer and flow through conduits; conduction; radiation; reactor core thermal analysis. (3 q.h. each)

5210 System Dynamics - Transient analysis, Laplace transforms, frequency response, stability (linear and nonlinear), and sensitivity analysis by state variable methods. Dynamic analysis of distributed systems. (3 q.h.)

5220 Reactor System Dynamics - Application of methods of general system dynamics to reactor systems. Modeling of neutronic and non-neutronic processes. Dynamics, stability, and control of zero power reactors and power reactor systems. (3 q.h.)

5230 Experimental Methods in Reactor Dynamics - Methods of measuring system dynamic characteristics in the time domain and frequency domain. Measurement, analysis, and interpretation of dynamics data using random and deterministic system perturbation. (3 q.h.)

5240 Reactor Instrumentation - Principles and applications of instrument components and systems for the operation, control, and safety of nuclear reactors; role of instrumentation in public health and safety; engineered safeguards for nuclear power plants. (3 q.h.)

5310-20-30 Nuclear Systems Reliability - Principles of system reliability analysis as applied to nuclear systems. Both qualitative and quantitative methods are included. (3 q.h. each)

5710-20-30 Nuclear Design - Development and application of analytical techniques for neutronic aspect of nuclear reactor core design. Techniques considered are multi-group discrete ordinate theory, multigroup PN theory, integral transport theory, perturbation theory, and others. The generation of the required multigroup constants is formulated starting with the available point data and using the Nordheim treatment in the slowing down region and gas kernel in the thermal region. (3 q.h. each)

5740 Reactor Shielding - Application of analytic solutions of Boltzman transport equation to shield design problems. Spherical harmonics, moments methods, numerical solutions, adjoint calculations, and invariant imbedding cases studied. (3 q.h.)

5790 Monte Carlo Shield Design - Analysis of radiation transport problems in shielding by the Monte Carlo Analysis method. Including random sampling, evaluation of integrals, analog particle transport, techniques of variance reduction. (3 q.h.)

5840-50 Fast Breeder Reactors - Special characteristics of fast breeder reactors, with emphasis on the LMFBR. The need for breeders; neutron physics and thermal characteristics of the reactor core; development status of engineering components; fuel cycle cost analysis; safety; coolants other than sodium; world status of development. (3 q.h. each)

5910-20 Advanced Nuclear Reactor Design - Factors affecting nuclear reactor design, and optimization with respect to performance criteria. Integration of neutronic, mechanical and thermal flow systems. Cycle, reactor plant cost estimating. (3 q.h. each)

5970 Special Topics in Nuclear Engineering - Lectures and recitation on recent advances in nuclear engineering. (3 q.h.)

5980 Nuclear Engineering Practice - Experiences in solving and reporting on engineering problems. Only Alternate Plan students may take this course. (3-12 q.h.)

6110-20-30 Selected Topics in Reactor Theory - Special topics related to reactor theory such as transport theory, control rod theory, and perturbation theory. Selected topics from the literature. (3 q.h. each)

6140 Radiation Shielding - Advanced topics in radiation shielding. Monte Carlo techniques and space radiation problems. Natural space radiators, dose conversion, probability, etc. Selected neutron, gamma, and space-radiation shielding problems. (3 q.h.)

6150 Reactor Dynamics - Special topics in reactor dynamics and control. (3 q.h.)

6710 Two-Phase Flow and Heat Transfer - Pool boiling and flow boiling; hydrodynamics of two-phase flow, boiling crises, two-phase instabilities. (3 q.h.)

INSTITUTION: WEST VIRGINIA INSTITUTE OF TECHNOLOGY

PROGRAM: Mining Engineering Technology

DEPARTMENT: Division of Engineering Technologies

DEGREE: Associate in Science (ASEMT)
Bachelor of Mining Engineering Technology (BEMT)

CONTACT: Dr. Thomas Jones
Chairman, Division of Engineering Technologies
West Virginia Institute of Technology
Montgomery, West Virginia 25136
(304) 442-3160

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The mining engineering technolgoy program offers students the option of a two or four year program in a highly specialized field of coal mining technology.

An Associate degree program was started in 1972 and followed by the Bachelor's degree program in 1976. It is a two plus two program in which students receive an ASEMT degree after two years of study and then may go into employment or continue on for an additional two years and receive the BEMT. Both programs can also be considered as terminal.

These programs have been structured to meet specific needs of the coal mining industry, the largest industry in the school's geographic area. They prepare students for careers such as engineering technician/supervisor, craft supervisor, project manager, and training or safety officer.

PROGRAM REQUIREMENTS

General requirements for admission to the program include a high school diploma or successful completion of the GED and at least one unit of algebra, one unit of integrated or plane geometry, and one half unit of trigonometry.

The Associate degree requires a minimum of seventy-one semester credits, which includes course work in basic subjects such as math, physics, drafting, general chemistry, and composition and rhetoric. The Bachelor's degree requires an additional sixty-four semester credits beyond the Associate level. The course work for this program includes fundamentals of management, economics, mine safety, and labor relations.

An optional co-op program is available in which students are concurrently employed with mining companies while pursuing the program. This option pays student tuition and fees and allows students to obtain the necessary work experience for supervisory positions. About twenty percent of the students participate in this option, which requires extra time for completion of the program.

CURRENT FACULTY, STUDENTS, GRADUATES

Four full-time faculty members are involved with both degree programs, supplemented by an additional seven part-time faculty in the ASEMT program and two part-time in the BEMT program. All faculty time is devoted to teaching.

Currently there are one hundred and fifty-five full-time and one hundred and fifty part-time students in the ASEMT program and thirty five full-time students enrolled in the BEMT program. Officials indicated that some of the students in the Associate program would be continuing on towards the Bachelor's degree, however, for the first two years all students are considered to be in the ASEMT program.

Most students, about ninety-five percent, come from West Virginia and usually are referred to the program from coal companies or recruited in local high schools. A majority of students currently in the BEMT program are career change, many of whom have other degrees, including some students with Master's degrees.

The ASEMT program graduates about eighteen students per year and is continually increasing in size. The Bachelor's program was only initiated in 1976, however, officials estimated that they expect to average approximately six graduates per year from this program. It is further anticipated that about fifty percent of future ASEMT students will continue on for the BEMT degree. Job placement has not been a problem for students. Coal companies recruit on campus through the college's placement service and almost all graduates are employed by the coal industry or support industries.

PROGRAM PROJECTIONS

Officials anticipate some expansion in program activities in the next year or two. A surface mining option is planned along with additional course offerings and the emphasis is on support services for the mining industry. This expansion may require up to three additional faculty members in the areas of mining and/or geology and civil engineering.

COURSE DESCRIPTION

(the following is a partial listing of courses)

86-101 Fundamentals of Mining & Safety Engineering - A basic survey course of exploration, evaluation, development, extraction unit operation, cycling, equipment, methods, and mineral economics as related to mining; mine safety engineering with emphasis on new laws. (3 s.h.)

86-102 Mining Laws & Management - Mining laws, both state and federal; means of implementation under practical mining situations; introduction to basic mining management. (3 s.h.)

86-204 Geology and Rock Mechanics - Basic physical geology; with emphasis on coal deposits and accompanying rock strata of the major coal basins of the U.S. (4 s.h.)

86-206 Mining Machinery and Control and Applications - A survey course on modern mining equipment for coal extraction; how it is possible to combine electrical and hydraulic conversions to produce practical coal mining machinery. (4 s.h.)

86-207 Mine Design and Ventilation and Drainage - Mine plant systems study; hauling, machinery requirements and selection; electrical and mechanical power transmission; drainage, ventilation preparation and waste disposal. (4 s.h.)

86-209 Preparation and Disposal - Basic chemistry of preparation, unit operations, flow sheets, and testing method used in preparation of coal; refuse and media disposal with its impact on ecology. (4 s.h.)

86-401 Mine Maintenance - Study of material to convince management that entire mine maintenance is basic to production and not a necessary evil. (3 s.h.)

86-402 Mine Safety Engineering - Analysis of problems of mine safety and accident prevention, compensation plans and laws, and mine property protection. (2 s.h.)

86-404 Mine Production Management - Basic techniques of industrial engineering as applied to mining. (3 s.h.)

86-406 Plant Design - Principles of mine haulage, hoisting pumping, mechanics, waste disposal, waste water and mine water treatment. (3 s.h.)

86-409 Mine Design - Application of rock mechanics, mine safety engineering, and plant design to a comprehensive design of an entire mine including underground developments and surface plant. (3 s.h.)

INSTITUTION: WEST VIRGINIA UNIVERSITY

PROGRAM: Engineering of Mines, Petroleum Engineering, Mineral Processing Engineering, Mineral Resource Economics

DEPARTMENT: Mining Engineering, Petroleum Engineering, Mineral Resource Economics, Mineral Processing Engineering (College of Mineral and Energy Resources)

DEGREE:

Bachelor of Science
Master of Science

CONTACT:

Dr. Jay H. Kelley
Dean of College of Mineral and Energy Resources
213 White Hall, Main Campus
West Virginia University
Morgantown, West Virginia 26501
(304) 293-5695

PROGRAM DESCRIPTION:

PROGRAM STRUCTURE

The College of Mineral and Energy Resources was first created in 1921 and is located in the center of one of the greatest mineral producing areas of the nation. It is located near industrial, mining, and petroleum and natural gas producing areas. Mining engineers plan, supervise, and operate mineral extraction processes. Petroleum and natural gas engineers are involved in exploration, drilling, production, and evaluation of oil and natural gas reservoirs. Mineral processing engineers are involved with extractive metallurgy, coal preparation, mineral benefication and energy conversion processes. Mineral and material recycling is likely to become an area of major emphasis in future years. Mineral and energy resource economics studies the economics of the mining industries and firms, economic resource evaluation, and public policy on resources. Positions are to be found in research, engineering, consulting, government service, and sales in all of the areas.

The College's mining and petroleum engineering curricula are fully accredited by the Engineer's Council for Professional Development. West Virginia University confers the professional degrees of Engineer of Mines (E.M.) and Petroleum Engineer (Pet.E.) upon graduates of the College of Mineral and Energy Resources on the basis of practical experience and study in absentia, the presentation of a thesis, and final oral examination. To be eligible, a candidate for the professional degree must have been in active practice of his profession for at least five years since receiving the first degree and must have been in responsible charge of important work for at least two years.

The College of Mineral and Energy Resources offers the following engineering curricula:

(1) A four-year curriculum leading to the degree of Bachelor of Science in Engineering of Mines.
(2) A four-year curriculum leading to the degree of Bachelor of Science in Petroleum Engineering.
(3) A combined science and engineering curriculum leading to the degree of Bachelor of Science and Bachelor of Science in Engineering of Mines or Bachelor of Science in Petroleum Engineering.
(4) A four-year curriculum leading to the degree of Bachelor of Science in Mineral Processing Engineering.
(5) Graduate curricula leading to the Master of Science in four fields--minering engineering, mineral processing engineering, mineral resource economics, and petroleum engineering. A Ph.D. is offered in these fields as well.

Laboratories are available for both teaching and research activities although they are presently considered to be inadequate. Four to five workshops are annually held for coal preparation, health and safety, and underground gas measurement for persons working in the field.

PROGRAM REQUIREMENTS

In order to be admitted to the College of Mineral and Energy Resources, students must be qualified to be admitted to West Virginia University and present secondary school credit for four units of English, two units of algebra, one unit of geometry, and one-half unit of trigonometry. Students must also take the American College Testing Program Test and forward the scores to the University. An applicant with a baccalaureate degree or its equivalent in the major field corresponding to the graduate study desired will be admitted on the same basis as graduates of the University.

At the undergraduate level (lower division), the first two years of instruction (70 semester hours of credit) are common to all programs. During the first two years, the student receives instruction in mathematics, geology, physics and chemistry. During the third and fourth years, instruction in the engineering sciences as well as in the professional subjects is given. Professional and general electives at both the lower and upper division levels are given in the areas of mineral and energy economics, mineral resources appraisal and exploration, design of mineral process operations and models of mineral commodity markets.

The mining engineering curriculum requires completion of a total of 140-141 semester hours of credit depending on the option selected. Options are available in underground mining, mine health and safety, and surface mining. Students in all options receive an introduction to the managerial, financial, environmental, and social aspects associated with operation of mine enterprise. Specializations in the fourth year are offered in coal mining, ore mining, or other phases of mining engineering.

The Petroleum Engineering curriculum requires completion of 137 semester hours of credit and incorporates courses from the study of geology and geological principles developed in courses related to oil field development and production. Courses are also available in property evaluation and in the humanities. In the senior year, electives are provided in developing management, supervisory skills, or in some special phase of petroleum and natural gas technology.

The mineral processing engineering curriculum requires completion of either 123 or 133 semester credits depending on the option selected. Options are available in coal preparation (133 credits), coal conversion (123), and metallurgy (133). Courses which develop skills in the chemical and physical principles employed in the mineral processing; those which provide insights into mechanical and thermal properties of minerals and fuels; and the specific courses of analysis, synthesis, and design of mineral-related processes are stressed in the program of study. Independent study is encouraged through special problems assignments, laboratories and design courses.

The M.S. degree program contains a minimum of 24 hours of course work and 6 hours of independent and original study in the minerals field leading to a master's thesis. At least 60 percent (18 hours) must be from 300-level or 400-level courses while the remainder can be made up of 200-level courses. Each candidate for a degree must select a major subject and submit a thesis. To establish eligibility for a degree and approval for candidacy for a graduate degree, faculty action is required.

The College has a cooperative program with participating companies which allows students to attend the University for half the year and work the other half. Summer employment is also available from a number of the largest oil and gas companies for petroleum engineering students.

Approximately 140 (20%) of the total enrollment of students in the College receive some form of financial assistance. Most of the funding for the assistance is provided by industry sources.

CURRENT FACULTY, STUDENTS, GRADUATES

The College of Mineral and Energy Resources has a total faculty of 23 from the divisions of Mining Engineering (4), Petroleum Engineering (4), Mineral Resource Economics (4), and Minerals Processing Engineering (2). Twenty-five faculty participate in research conducted by the College's Coal Research Bureau. Eight faculty members are full-time teaching members of the faculty and three are from the division of Mining Engineering; two are from Petroleum Engineering; and one each are from Mineral Resource Economics and Mineral Processing. Most research funding comes from the U.S. Department of Energy, West Virginia State and the Electric Power Research Institute.

PROGRAM PROJECTIONS

A greater environmental emphasis is projected for development in the water, noise, and subsidance areas. A pedology course is likely to be added to the surface mining option in the future and it would most likely be the best offered of its kind in the nation. Resource conservation is another area with growth potential in the future. The pedology program (the study of soils and transformation of rocks) will necessitate the hiring of additional faculty although there is a possibility of sharing staff to offer the course with the agriculture college.

The Engineering of Mines degree programs are the largest of any offered by the College of Mineral and Energy Resources. This program also is most likely to continue to grow in enrollment in subsequent years.

COURSE DESCRIPTION

(the following is a partial listing of courses)

General Minerals Program % Conservation

1 Mineral Engineering Problem Solving - Freshman orientation to the College of Mineral and Energy Resources. Basic engineering graphics, vectors, descriptive geometry, area and volume, sedimentary rocks and map interpretation, drafting and lettering. (3 s.h.) 50%

19 Energy Technologies for the Future - Technological aspects of the energy crisis with special attention to upcoming systems likely to influence energy production patterns. (3 s.h.) 50%

97 Man's Energy Needs and Resource Limitations - Dilemmas posed for backward and modern societies by rising energy demands amid concerns for the world's environment, given existing resources constraints. Conventional technologies and historical concerns over resource scarcities. Implications for welfare economics. Impact of technological change and both future and exotic energy systems. (3 s.h.) 75%

200 Elements of Mineral Conservation - Economics of conservation for nonrenewable resources; traditional and modern views; new environmentalist concerns. Current and forecast demand and supply conditions for mineral and energy resources; causes of

200 (Cont.) mineral loss and environmental costs in production and utilization; methods of environmental control and conservation in underground and surface mining. (3 s.h.) 90%

Engineering of Mines

221 Mine Design II - Design principles and methods pertaining to mine water treatment, refuse disposal and treatment, other topics. (2 s.h.) 40%

247 Explosives Engineering - Theory and application of explosives, composition and characteristics of explosives, blasting design fundamentals, legal and safety considerations. (3 s.h.) 50% Noise & Shock

Petroleum Engineering (% salt brime pollution-stream pollution)

210 Drilling Engineering - Rock properties, well-bore hydraulics, air lifting capacity lizuid, air, or gas, two-phase flow, casing and casing string design, well-bore primary and squeeze cementing, vertical and directional drilling, minimum cost drilling. (3 s.h.) 35%

342 Well Stimulation by Hydraulic Fracturing - Hydraulic fracturing fluids. Parameters involved in fracturing. Fracture initiation, orientation, and extension. Productivity increase after fracturing. Proofing agents and general fracturing treatment design. (3 s.h.) 35%

Mineral Processing Engineering (% water pollution)

103 Physical and Chemical Changes in Mineral Beneficiation and Utilization - Mineral processing fundamentals form the view point of chemical and physical changes including float-sink phenomena, froth-flotation effects, and others. (4 s.h.) 30%

217 Coal Preparation - Formation of coal, rank classification of coal, coal petrography, principles of preparing and beneficiating coal for market with laboratory devoted to sampling, screen analysis, float and sink separation, and use of various types of coal cleaning equipment. (3 s.h.) 45%

224 Mineral Problems - Special problems considered in mineral beneficiation and processing, including choices among design and research projects in coal preparation, coal conversion, (process) hydro- and extractive metallurgy or minerals economy. (1-9 s.h.) 40%

Mineral Resources Program (% conservation & environmental)

101 Principles of Resource and Energy Economics - Analyzes background for problems important or peculiar to mineral industry economics. The analyses of monopoly regulation, antitrust action, and resource planning are presented, and projections made for energy, major metals and industrial minerals. (3 s.h.) 30%

222 Energy Economics - Analyzes energy sector of the economy, inter-fuel competition, current and future markets, and international trade. New energy technologies. (3 s.h.) 20%

305 Transportation of Solids and Fluids - Study is made of the complex systems required for transportation of solids and minerals. (3 s.h.) 10%

332 Substitute Liquid Fuel Processes - Heat and mass transfer and systematic methods of materials and energy balances. Energy conversion processes for coal gasification, retorting tar sands, oil shales, and underground storage of natural gas. (3 s.h.) 30%

350 Readings in Mineral Resource and Energy Economics - Review of current mineral economic studies. Selected authors in mineral science and engineering, the economics of natural resource exploitation and environmental control, national mineral policy, world mineral development and trade. (3 s.h.) 15%

381 Theory and Policy of Mineral Economics - Defines the pure theory of resources and energy allocation with technologic, and environmental constraints. A general model is presented with partial and special applications for major problem areas: resource valuation, conservation, exhaustion, taxation, and trade. Problems of imperfect competition and monopoly open consideration to the foundations of policy in practice and theory. (3 s.h.) 20%

392 The Economics of the Energy and Petrochemical Sectors - Energy and petrochemical complexes are defined within an open activity analysis model. The problems explored include forecasting energy demands, joint production and costing, environmental controls, and impacts on regional and international trade. (3 s.h.) 20%

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APPENDICES

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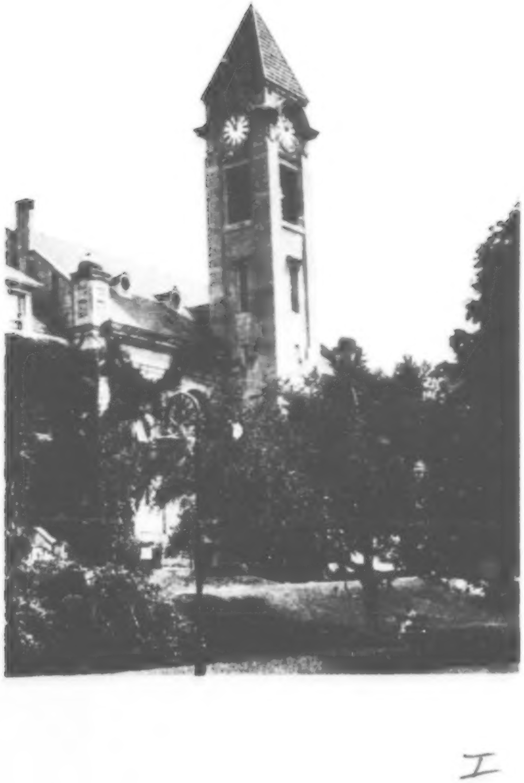

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APPENDIX I

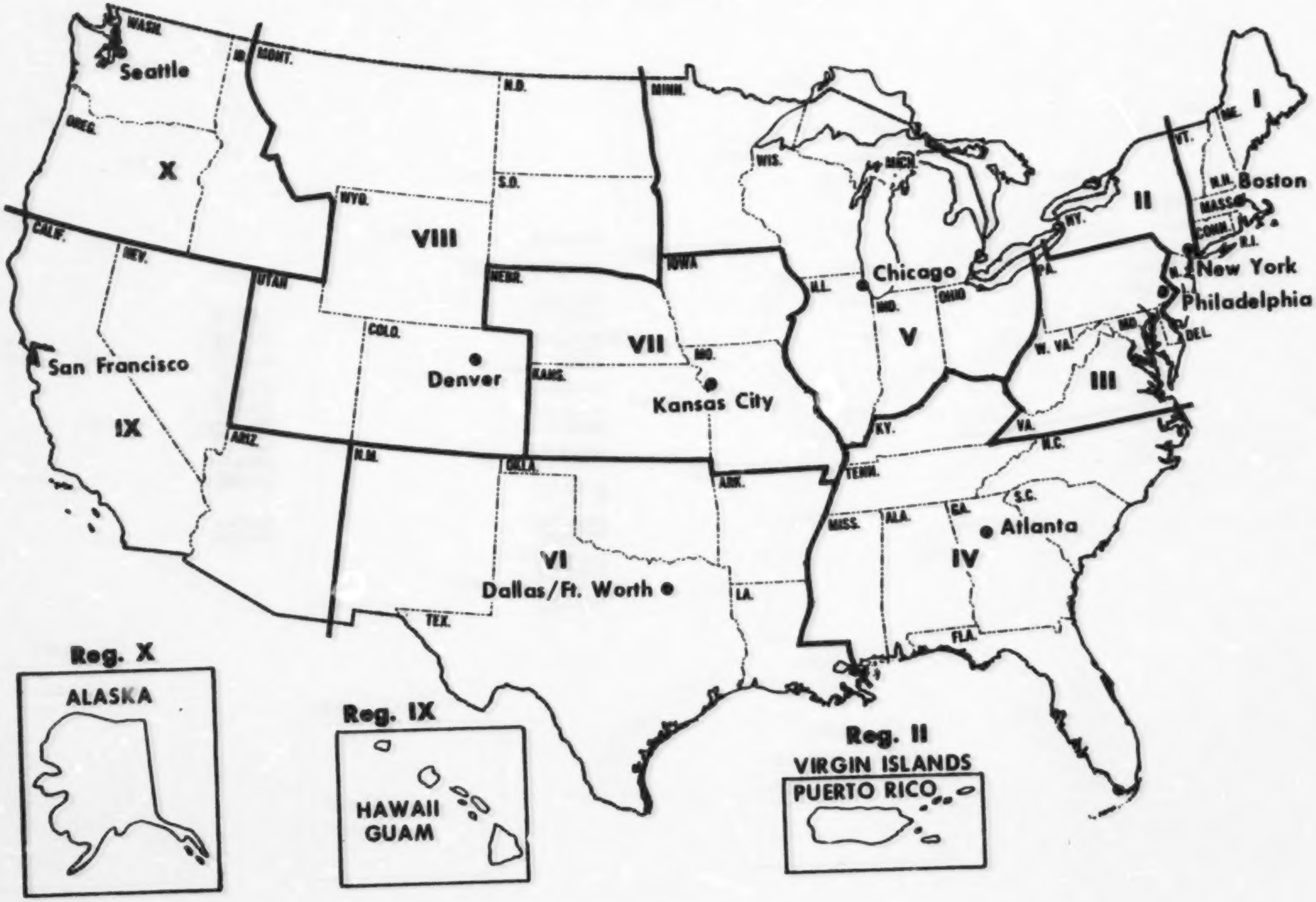
Degree Abbreviations

A.A.	Associate of Arts
A.A.Ag.	Associate of (in) Applied Agriculture
A.Ag.	Associate of (in) Agriculture
A.A.P.C.T.	Associate Degree in Air Pollution Control Technology
A.A.S.	Associate of Applied Science
A.B.	Bachelor of Arts
A.D.	Associate Degree
A.E.T.	Associate in Engineering Technology
A.M.T.	Associate of Mining Technology
A.N.E.T.	Associate of Nuclear Engineering Technology
A.S.	Associate in Science
A.S.E.M.T.	Associate of Science in Engineering Mining Technology
A.T.	Associate of Technology
B.A.	Bachelor of Arts
B.E.M.T.	Bachelor of Engineering in Mining Technology
B.S.	Bachelor of Science
B.S. (N.E.)	Bachelor of Science in Nuclear Engineering
B.S. (N.E.S.)	Bachelor of Science (Nuclear Engineering Sciences)
B.S. (N.R.)	Bachelor of Science in Natural Resources
B.S.A.	Bachelor of Science in Agriculture
B.S.C.E.	Bachelor of Science in Civil Engineering
B.S.Ch.E.	Bachelor of Science in Chemical Engineering
B.S.E.	Bachelor of Science in Engineering
B.S.E.H.	Bachelor of Science in Environmental Health
B.S.E. (N.E.)	Bachelor of Science (Nuclear Engineering)
B.S.E.S.	Bachelor of Science in Engineering Sciences
B.S.N.E.	Bachelor of Science in Nuclear Engineering
B.T.	Bachelor of Technology
Cert.	Certificate

D.E.	Doctor of Engineering
D.P.H.	Doctor of Public Health
D.S.	Doctor of Science
D.S. (Hyg.)	Doctor of Science Hygiene
D.Sc.	Doctor of Science
Dr.P.H.	Doctor of Public Health
E.E.	Environmental Engineer
Eng.	Engineer
Engr.	Engineer
Engr.Sc.D.	Doctor of Engineering Science
Env.E.	Environmental Engineer
Envir.Eng.	Environmental Engineer
M.A.	Master of Arts
M.Ag.	Master of Agriculture
M.Agr.	Master of Agriculture
M.A.S.	Master of Applied Science
M.C.E.	Master of Civil Engineering
M.E.	Master of Engineering
M.E.E.E.	Master of Engineering in Environmental Engineering
M.E.A.S.	Master of Environmental Arts and Science
M.E.H.S.	Master of Environmental Health Sciences
M.E.M.	Master of Environmental Management
M.E.P.C.	Master in Environmental Pollution Control
M.Eng.	Master of Engineering
M.Engr.	Master of Engineering
M.F.	Master of Forestry
M.M.E.	Master of Mechanical Engineering
M.P.	Master of Philosophy
M.P.A.	Master of Public Affairs
M.P.H.	Master of Public Health
M.P.P.P.M.	Master of Plant Protection and Pest Management

M.P.S.	Master of Professional Studies
M.S.	Master of Science
M.S. (Hyg.)	Master of Science Hygiene
M.S.C.E.	Master of Science in Civil Engineering
M.S.Ch.E.	Master of Science in Chemical Engineering
M.S.E.	Master of Science in Engineering
M.S.E.E.	Master of Science in Environmental Engineering
M.S.En.E.	Master of Science in Environmental Engineering
M.S.Eng. S.	Master of Science in Environmental Engineering
M.S.Eng. Sci.	Master of Science in Engineering Science
M.S.E.H.	Master of Science in Environmental Health
M.S.E.M.P.	Master of Science in Energy Management and Policy
M.S.E.S.	Master of Science in Environmental Science (Studies)
M.S.P.H.	Master of Science in Public Health
M.S.(S.E.)	Master of Science in Sanitary Engineering
M.S.(S.S.)	Master of Science in Sanitary Science
N.E.	Nuclear Engineering
Nuc. Eng.	Nuclear Engineering
Ph.D.	Doctor of Philosophy
S.B.	Bachelor of Science
Sc.D.	Doctor of Science
S.M.	Master of Science

STANDARD REGIONAL BOUNDARIES
TEN REGIONS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MINN.
NEBR.
COLO.
Denver
San Francisco
IX
ARIZ.
N.M.
KANS.
VII
IOWA
MO.
Kansas City
OKLA.
ARK.
VI
Dallas/Ft. Worth
TEX.
LA.
WIS.
MICH.
ILL.
Chicago
IND.
V
OHIO
KY.
TENN.
MISS.
ALA.
GA.
S.C.
Atlanta
IV
FLA.
N.C.
VA.
W. VA.
MD.
DEL.
III
PA.
N.Y.
II
N.J.
New York
Philadelphia
VT.
ME.
I
N.H.
Boston
MASS.
CONN.
R.I.
Reg. X
ALASKA
Reg. IX
HAWAII
GUAM
Reg. II
VIRGIN ISLANDS
PUERTO RICO

TERMINOLOGY

ACT (American College Testing) and SAT (Scholastic Aptitude Test) - Standardized examinations which are intended to provide applicants and institutions with a numerical statement of an individual's ability and readiness to successfully complete college/university level work.

Co-op program - A plan whereby a student receives financial assistance and academic credit under the direction of a cooperating employment site representative and a faculty advisor in exchange for an agreed upon condition of employment. Students must complete all degree requirements as per the norm.

Course - For the purpose of this study, a course is considered a unit of a program, in which a body of knowledge is presented, the satisfactory completion of which leads to the awarding of a predetermined or individually arranged number of credits.

ECPD (Engineers' Council for Professional Development) - Accrediting body for programs in engineering technology.

ERIC (Educational Resources Information Center) - A national information system designed and developed by the U.S. Office of Education, and now supported and operated by the National Institute of Education (NIE), for providing ready access to descriptions of exemplary programs, research and development efforts, and related information that can be used in developing more effective educational programs.

GRE (Graduate Record Examination) - (General Aptitude) An examination of verbal and mathematical competency and aptitude, which is designed to provide a numerical indication of an individual's ability to successfully complete advanced level work. For the purposes of the study, the GRE will not refer to the Advanced Examinations.

Internship/Applied Study Term - An arrangement which is intended to provide a simulation of work experience under the direction of academic advisors and is designed to be an integral segment of an individual's academic program. (College credit may be given.)

IRIS (Instructional Resources Information System) - A computerized information base listing materials relating to education and training in the water quality control field, which is located in the National Training and Operational Technology Center of the U.S. Environmental Protection Agency.

MEDLINE - Computerized literature search services with application to medical information.

NTIS (National Technical Information Service) - Computerized literature search services.

Program - For the purpose of this study, a plan of study, either completely prescribed, or containing options, with an identity of its own, and standard rules and procedures, the satisfaction of which may lead to a degree, certificate, or diploma.

Quarter hours - vs. - Semester hours - One semester hour is the credit equivalent to one and a half quarter hours.

Standard Federal Boundaries - Geographic division of the United States for the purposes of decentralized administration; in this report also referred to as EPA regions (see map on preceding page).

TOXLINE - Computerized literature search services with particular application to the recall of information concerning toxic substances.

WRSIC (Water Resources Scientific Information Center) - Collects, screens, organizes and disseminates reports in water resources.

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APPENDIX IV

PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
AIR	Carnegie-Mellon University	Pittsburgh, PA
	Clemson University	Clemson, SC
	Drexel University	Philadelphia, PA
	George Washington University-NASA	Hampton, VA
	Harvard University School of Public Health	Boston, MA
	Hudson Valley Community College	Troy, NY
	Massachusetts Institute of Technology	Ithaca, NY
	Michigan Technological University	Houghton, MI
	Middlesex County College	Edison, NJ
	Muskingum Area Technical College	Zanesville, OH
	New Jersey Institute of Technology	Newark, NJ
	North Carolina State University	Chapel Hill, NC
	North Dakota State School of Science	Wahpeton, ND
	Northeastern University	Boston, MA
	Ohio State University	Columbus, OH
	Portland State University	Portland, OR
	Prairie State Community College	Chicago Heights, IL
	Purdue University	West Layfayette, IN
	Rensselaer Polytechnic Institute	Troy, NY
	Rutgers-The State University of New Jersey	New Brunswick, NJ
	Springfield Technical Community College	Springfield, MA
	Stevens Institute of Technology	Hoboken, NJ
	Sumter University	Sumter, SC
	Syracuse University	Syracuse, NY
	Temple University	Philadelphia, PA
	The Pennsylvania State University	University Park, PA
	University of Cincinnati	Cincinnati, OH
	University of Delaware	Newark, DE
	University of Florida	Gainesville, FL
	University of Iowa	Iowa City, IA
	University of Kentucky	Lexington, KY
	University of Maryland	College Park, MD
	University of Michigan	Ann Arbor, MI
	University of Missouri-Rolla	Rolla, MO
	University of North Carolina	Chapel Hill, NC
	University of Pittsburgh	Pittsburgh, PA
	University of Tennessee	Knoxville, TN
	University of Texas-Austin	Austin, TX
	University of Washington	Seattle, WA
	University of Wisconsin-Milwaukee	Milwaukee, WI
	Vanderbilt University	Nashville, TN
	Washington State University	Pullman, WA
	Washington University	St. Louis, MO
	West Virginia University	Morgantown, WV
	Yale University	New Haven, CT

APPENDIX IV

PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
COMPOSITE:	Antioch College	Yellow Springs, OH
	Baylor University	Waco, TX
	Bemidji State University	Bemidji, MN
	California Institute of Technology	Pasadena, CA
	California Polytechnic State University	San Luis Obispo, CA
	Catholic University of America	Washington, DC
	Carnegie-Mellon University	Pittsburgh, PA
	Chattanooga State Technical Community College	Chattanooga, TN
	Clarkson College	Potsdam, NY
	Clemson University	Clemson, SC
	Cornell University	Ithaca, NY
	Delaware Technical and Community College	Newark, DE
	Delgado College	New Orleans, LA
	Drexel University	Philadelphia, PA
	Duke University	Durham, NC
	East Central Oklahoma State University	Ada, OK
	East Tennessee State University	Johnson City, TN
	Evergreen State College	Olympia, WA
	Ferris State College	Big Rapids, MI
	Florida International University	Miami, FL
	Georgia Institute of Technology	Atlanta, GA
	Heed University	Hollywood, FL
	Hocking Technical College	Nelsonville, OH
	Howard University	Washington, DC
	Hunter College	New York, NY
	Indiana University	Bloomington, IN
	Iowa State University	Ames, IA
	Johns Hopkins University	Baltimore, MD
	Kansas State University	Manhattan, KS
	Kirkwood Community College	Cedar Rapids, IA
	Lamar University	Beaumont, TX
	Macalester College	St. Paul, MN
	Massachusetts Institute of Technology	Cambridge, MA
	McNeese State University	Lake Charles, LA
	Miami University	Oxford, OH
	Michigan State University	East Lansing, MI
	Middle Tennessee State University	Murfreesboro, TN
	Morehead State University	Morehead, KY
	Muskingum Area Technical College	Zanesville, OH
	New Jersey Institute of Technology	Newark, NJ
	North Carolina State University	Raleigh, NC
	Northland College	Ashland, WI
	Ohio State University	Columbus, OH

APPENDIX IV

PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
COMPOSITE: (Cont'd)	Ohio University	Athens, OH
	Oscar Rose Junior College	Midwest City, OK
	OSU Oklahoma City Technical Institute	Oklahoma City, OK
	Polytechnical Institute of New York	Brooklyn, NY
	Princeton University	Princeton, NJ
	Purdue University	West Lafayette, IN
	Raymond Walters General and Technical College (University of Cincinnati	Cincinnati, OH
	Rensselaer Polytechnical Institute	Troy, NY
	Rutgers University	New Brunswick, NJ
	Sam Houston State University	Huntsville, TX
	Sangamon State University	Springfield, IL
	Slippery Rock State College	Slippery Rock, PA
	Springfield Technical and Community College	Springfield, MA
	Stevens Institute of Technology	Hoboken, NJ
	Syracuse University	Syracuse, NY
	Temple University	Philadelphia, PA
	Texas A & M University	College Station, TX
	The Cooper Union	New York, NY
	The Pennsylvania State University	University Park, PA
	University of Alabama	University, AL
	University of Alaska	Fairbanks, AK
	University of Arkansas	Fayetteville, AR
	University of California-Santa Barbara	Santa Barbara, CA
	University of Cincinnati	Cincinnati, OH
	University of Delaware	Newark, DE
	University of Florida	Gainesville, FL
	University of Georgia	Athens, GA
	University of Kansas	Lawrence, KS
	University of Louisville	Louisville, KY
	University of Maine-Orono	Orono, Maine
	University of Michigan	Ann Arbor, MI
	University of Minnesota	Minneapolis, MN
	University of North Carolina	Chapel Hill, NC
	University of Oklahoma	Norman, OK
	University of Pittsburgh	Pittsburgh, PA
	University of Tennessee	Knoxville, TN
	University of Toledo	Toledo, OH
	University of Utah	Salt Lake City, UT
	University of Washington	Seattle, WA
	University of Wisconsin-Green Bay	Green Bay, WI
	University of Wisconsin-Madison	Madison, WI
	Utah State University	Logan, UT

APPENDIX IV

PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
COMPOSITE: (Cont'd)	Vanderbilt University	Nashville, TN
	Virginia Polytechnic Institute and State University	Blacksburg, VA
	Washington State University	Pullman, WA
	Western Kentucky University	Bowling Green, KY
	Western Washington University (Huxley College of Environmental Studies)	Bellingham, WA
	West Virginia University	Morgantown, WV
	Yale University	New Haven, CT
ENERGY:	Bluefield State College	Bluefield, WV
	Brigham Young University	Provo, UT
	Carnegie-Mellon University	Pittsburgh, PA
	Columbia University	New York, NY
	Cornell University	New York, NY
	Georgia Institute of Technology	Atlanta, GA
	Hartford State Technical College	Hartford, CT
	Kansas State University	Manhattan, KS
	Lamar University	Beaumont, TX
	Massachusetts Institute of Technology	Cambridge, MA
	Morehead State University	Morehead, KY
	Muskingum Area Technical College	Zanesville, OH
	Oregon State University	Corvallis, OR
	Pikeville College	Pikeville, KY
	Polytechnic Institute of New York	Brooklyn, NY
	Princeton University	Princeton, NJ
	Purdue University	West Lafayette, IN
	Rensselaer Polytechnic Institute	Troy, NY
	Southern Technical Institute	Marietta, GA
	Texas State Technical Institute	Waco, TX
	The Pennsylvania State University	University Park, PA
	University of California-Berkeley	Berkeley, CA
	University of Florida	Gainesville, FL
	University of Kentucky	Lexington, KY
	University of New Mexico	Albuquerque, NM
	University of Pennsylvania	Philadelphia, PA
	University of Tennessee	Knoxville, TN
	West Virginia Institute of Technology	Montgomery, WV
	West Virginia University	Morgantown, WV

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PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
NOISE:	George Washington University-NASA	Hampton, VA
	Georgia Institute of Technology	Altanta, GA
	Massachusetts Institute of Technology	Cambridge, MA
	Memphis State University	Memphis, TN
	North Carolina State University	Raleigh, NC
	The Pennsylvania State University	University Park, PA
	University of Cincinnati	Cincinnati, OH
	University of Pittsburgh	Pittsburgh, PA
	University of Tennessee	Knoxville, TN
	University of Tennessee Center for Health Sciences	Memphis, TN
PESTICIDES:	Abraham Baldwin Agricultural College	Tifton, GA
	Broward Community College	Ft. Lauderdale, FL
	Central Technical Community College	Hastings, NE
	Delgado Community College	New Orleans, LA
	Harvard University School of Public Health	Boston, MA
	Mississippi State University	Mississippi State, MS
	New Mexico State University	Las Cruces, NM
	North Carolina State University	Raleigh, NC
	Ohio State University	Columbus, OH
	Oregon State University	Corvallis, OR
	Rutgers State University of New Jersey	New Brunswick, NJ
	State University of New York at Farmingdale	Farmingdale, NY
	Texas A & M University	College Station, TX
	The Pennsylvania State University	University Park, PA
	University of California-Berkeley	Berkeley, CA
	University of California-Davis	Davis, CA
	University of California-Riverside	Riverside, CA
	University of Cincinnati	Cincinnati, OH
	University of Delaware	Newark, DE
	University of Georgia	Athens, GA
	University of Iowa	Iowa City, IA
	University of Maryland	College Park, MD
	University of New Hampshire	Durham, NH
	University of Pittsburgh	Pittsburgh, PA
	University of Rochester	Rochester, NY
	Utah State University	Logan, UT

APPENDIX IV

PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
POTABLE WATER:	Atlanta University Center/Georgia Institute of Technology	Atlanta, GA
	Brigham Young University	Provo, UT
	California State University	Sacramento, CA
	Carnegie-Mellon University	Pittsburgh, PA
	Casper College	Casper, WY
	Central Technical Community College	Hastings, NE
	Clarkson College	Potsdam, NY
	Clemson University	Clemson, SC
	Colorado State University	Fort Collins, CO
	Community College of Denver-Red Rocks	Golden, CO
	Cornell University	Ithaca, NY
	Delgado College	New Orleans, LA
	Drexel University	Philadelphia, PA
	East Maine Vocational Technical Institute	Bangor, ME
	Hudson Valley Community College	Troy, NY
	Illinois Institute of Technology	Chicago, IL
	Iowa State University	Ames, IA
	J. Sargeant Reynolds Community College	Richmond, VA
	Kansas State University	Manhattan, KS
	Kirkwood Community College	Cedar Rapids, IA
	Linn-Benton Community College	Albany, OR
	Manhattan College	New York, NY
	Marquette University	Milwaukee, WI
	Massachusetts Institute of Technology	Cambridge, MA
	Miami-Dade Community College	Miami, FL
	Michigan Technological University	Houghton, MI
	Middlesex Community College	Edison, NJ
	Missouri Southern State College	Joplin, MO
	Montana State University	Bozeman, MT
	Muskingum Area Technical College	Zanesville, OH
	Northeastern University	Boston, MA
	Northern Montana College	Havre, MT
	Ohio State University	Columbus, OH
	Operator Training Center	Murfreesboro, TN
	Oregon Institute of Technology	Klamath Falls, OR
	Oscar Rose Junior College	Midwest City, OK
	Purdue University	West Lafayette, IN
	Rensselaer Polytechnic Institute	Troy, NY
	Rice University	Houston, TX
	Rochester Institute of Technology	Rochester, NY
	Rutgers State University of New Jersey	New Brunswick, NJ
	Southern Illinois University	Edwardsville, IL

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PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
POTABLE WATER: (Cont'd)	Springfield Technical Community College	Springfield, MA
	Stanford University	Stanford, CA
	State University of New York at Buffalo	Buffalo, NY
	Stevens Institute of Technology	Hoboken, NJ
	Sumter Technical Community College	Sumter, SC
	Syracuse University	Syracuse, NY
	Temple University	Philadelphia, PA
	Texas State Technical Institute	Waco, TX
	The Pennsylvania State University	University Park, PA
	The Pennsylvania State University/ Capitol Campus	Middletown, PA
	Tufts University	Boston, MA
	Ulster County Community College	Stone Ridge, NY
	University of California-Berkeley	Berkeley, CA
	University of Florida	Gainesville, FL
	University of Hawaii	Honolulu, HI
	University of Iowa	Iowa City, IA
	University of Kansas	Lawrence, KS
	University of Kentucky	Lexington, KY
	University of Maine at Orono	Orono, ME
	University of Michigan	Ann Arbor, MI
	University of Missouri-Columbia	Columbia, MO
	University of Missouri-Rolla	Rolla, MO
	University of Nebraska	Lincoln, NE
	University of North Carolina	Chapel Hill, NC
	University of Pennsylvania	Philadelphia, PA
	University of Pittsburgh	Pittsburgh, PA
	University of Rhode Island	Kingston, RI
	University of Tennessee	Knoxville, TN
	University of Texas-Austin	Austin, TX
	University of Wisconsin-Madison	Madison, WI
	University of Wyoming	Laramie, WY
	Utah State University	Logan, UT
	Vanderbilt University	Nashville, TN
	Virginia Polytechnic Institute and State University	Blacksburg, VA
	Water and Wastewater Technical School	Neosho, MO
	West Georgia College	Carrollton, GA
	West Virginia University	Morgantown, WV
	Wytheville Community College	Wytheville, VA

APPENDIX IV

PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
RADIATION:	Central Florida Community College	Ocala, FL
	Chattanooga State Technical Community College	Chattanooga, TN
	Columbia University	New York, NY
	Cornell University	Ithaca, NY
	Hartford State Technical College	Hartford, CT
	Harvard University School of Public Health	Boston, MA
	Kansas State University	Manhattan, KS
	Massachusetts Institute of Technology	Cambridge, MA
	Memphis State University	Memphis, TN
	Missouri Southern State College	Joplin, MO
	Oak Ridge Associated Universities	Oak Ridge, TN
	Oklahoma State University	Stillwater, OK
	Rensselaer Polytechnic Institute	Troy, NY
	Rutgers State University of New Jersey	New Brunswick, NJ
	St. Louis Community College at Forest Park	St. Louis, MO
	Southern Technical Institute	Marietta, GA
	The Pennsylvania State University	University Park, PA
	University of Florida	Gainesville, FL
	University of Kansas	Lawrence, KS
	University of Lowell	Lowell, MA
	University of Maryland	College Park, MD
	University of Michigan	Ann Arbor, MI
	University of North Carolina	Chapel Hill, NC
	University of Pittsburgh	Pittsburgh, PA
	University of Tennessee	Knoxville, TN
SOLID WASTE:	Carnegie-Mellon University	Pittsburgh, PA
	Clarkson College	Potsdam, NY
	Cornell University	New York, NY
	Drexel University	Philadelphia, PA
	Hofstra University	Hempstead, NY
	Michigan Technological University	Houghton, MI
	Rensselaer Polytechnic Institute	Troy, NY
	Temple University	Philadelphia, PA
	The Pennsylvania State University	University Park, PA
	University of Iowa	Iowa City, IA
	University of Missouri-Rolla	Rolla, MO
	University of Pittsburgh	Pittsburgh, PA
	Vanderbilt University	Nashville, TN
	West Virginia University	Morgantown, WV
	Wilson County Technical Institute	Wilson, NC
	Yale University	New Haven, CT

APPENDIX IV

PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
WASTEWATER:	Atlanta University Center/ Georgia Institute of Technology	Atlanta, GA
	Brigham Young University	Provo, UT
	California State University-Sacramento	Sacramento, CA
	Carnegie-Mellon University	Pittsburgh, PA
	Casper College	Casper, WY
	Central Technical Community College	Hastings, NE
	Charles County Community College	La Plata, MD
	Clarkson College	Potsdam, NY
	Clemson University	Clemson, SC
	Colorado State University	Fort Collins, CO
	Community College of Denver-Red Rocks	Golden, CO
	Cornell University	Ithaca, NY
	Delgado College	New Orleans, LA
	Drexel University	Philadelphia, PA
	East Maine Vocational Technical Institute	Bangor, ME
	Greenville Technical College	Greenville, SC
	Harvard University	Cambridge, MA
	Hudson Valley Community College	Troy, NY
	Illinois Institute of Technology	Chicago, IL
	Iowa State University	Ames, IA
	J. Sargeant Reynolds Community College	Richmond, VA
	Kansas State University	Manhattan, KS
	Kirkwood Community College	Cedar Rapids, IA
	Linn-Benton Community College	Albany, OR
	Manhattan College	New York, NY
	Marquette Technical University	Milwaukee, WI
	Massachusetts Institute of Technology	Cambridge, MA
	Miami-Dade Community College	Miami, FL
	Michigan Technological University	Houghton, MI
	Middlesex County College	Edison, NJ
	Missouri Southern State College	Joplin, MO
	Montana State University	Bozeman, MT
	Muskingum Area Technical College	Zanesville, OH
	New England Regional Wastewater Institute	S. Portland, ME
	New Jersey Institute of Technology	Newark, NJ
	Northeastern University	Boston, MA
	Northern Montana College	Havre, MT
	Ohio State University	Columbus, OH
	Operator Training Center	Murfreesboro, TN
	Oregon Institute of Technology	Klamath Falls, OR
	Oscar Rose Junior College	Midwest City, OK

APPENDIX IV

PARTICIPATING INSTITUTIONS BY ENVIRONMENTAL CATEGORY

CATEGORY	INSTITUTION	LOCATION
WASTEWATER: (Cont'd)	Purdue University	West Lafayette, IN
	Rensselaer Polytechnic Institute	Troy, NY
	Rice University	Houston, TX
	Rochester University	Rochester, NY
	Rutgers State University of New Jersey	New Brunswick, NJ
	Southern Illinois University	Edwardsville, IL
	Springfield Technical and Community College	Springfield, MA
	Stanford University	Stanford, CA
	State Technical Institute at Memphis	Memphis, TN
	State University of New York-Buffalo	Buffalo, NY
	Stevens Institute of Technology	Hoboken, NJ
	Sumter Technical Community College	Sumter, SC
	Syracuse University	Syracuse, NY
	Temple University	Philadelphia, PA
	Texas State Technical Institute	Waco, TX
	The Pennsylvania State University	University Park, PA
	The Pennsylvania State University/ Capitol Campus	Middletown, PA
	Tufts University	Boston, MA
	Ulster County Community College	Stone Ridge, NY
	University of California-Berkeley	Berkeley, CA
	University of Florida	Gainesville, FL
	University of Hawaii	Honolulu HI
	University of Kansas	Lawrence, KS
	University of Kentucky	Lexington, KY
	University of Lowell	Lowell, MA
	University of Maine at Orono	Orono, ME
	University of Missouri-Columbia	Columbia, MO
	University of Missouri-Rolla	Rolla, MO
	University of Nebraska	Lincoln, NE
	University of North Carolina	Chapel Hill, NC
	University of Pittsburgh	Pittsburgh, PA
	University of Rhode Island	Kingston, RI
	University of Tennessee	Knoxville, TN
	University of Texas	Austin, TX
	University of Wisconsin-Madison	Madison, WI
	University of Wyoming	Laramie, WY
	Utah State University	Logan, UT
	Vanderbilt University	Nashville, TN
	Virginia Polytechnic Institute and State University	Blacksburg, VA
	Water and Wastewater Technical School	Neosho, MO
	West Georgia College	Carrollton, GA
	West Virginia University	Morgantown, WV
	Wytheville Community College	Wytheville, VA

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
AL	Alabama A & M University	Huntsville
	Alabama Christian College	Montgomery
	Alabama Lutheran Junior College	Selma
	Alexander City State Junior College	Alexander City
	Athens State College	Athens
	Auburn University	Auburn
	Auburn University at Montgomery	Montgomery
	Birmingham-Southern College	Birmingham
	Brewer State Junior College	Fayette
	Enterprise State Junior College	Enterprise
	Faulkner State Junior College	Bay Minette
	Gadsden State Junior College	Gadsden
	George C. Wallace State Community College	Dothan
	George C. Wallace State Community College	Selma
	Jacksonville State University	Jacksonville
	Jefferson Davis State Junior College	Brewton
	Jefferson State Junior College	Birmingham
	John C. Calhoun State Community College	Decatur
	Judson College	Marion
	Livingston University	Livingston
	Lawson State Community College	Birmingham
	Lurleen B. Wallace State Junior College	Andalusia
	Marion Military Institute	Marion
	Miles College	Birmingham
	Mobile College	Mobile
	Northeast Alabama State Junior College	Rainsville
	Northwest Alabama State Junior College	Phil Campbell
	Oakwood College	Huntsville
	Samford University	Birmingham
	Selma University	Selma
	Snead State Junior College	Boaz
	Southeastern Bible College	Birmingham
	Southern Benedictine College	Saint Bernard
	Southern Union State Junior College	Wadley
	Spring Hill College	Mobile
	Stillman College	Tuscaloosa
	Talladega College	Talladega
	Troy State University	Troy
	Tuskeegee Institute	Tuskeegee Institute
	University of Alabama	University
	University of Alabama in Birmingham	Birmingham
	University of Alabama in Huntsville	Huntsville
	University of Montevallo	Montevallo
	University of North Alabama	Florence
	University of South Alabama	Mobile
	Walker College	Jasper
AK	Sheldon Jackson College	Sitka
	University of Alaska-Fairbanks	Fairbanks
	University of Alaska Juneau Senior College	Juneau
AS	American Samoa Community College	Pago Pago
AZ	American Graduate School of International Management	Glendale
	Arizona State University	Tempe
	Arizona Western College	Yuma

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Central Arizona College	Coolidge
	Cochise College	Douglas
	College of Ganado	Ganado
	DeVry Institute of Technology	Phoenix
	Eastern Arizona College	Thatcher
	Grand Canyon College	Phoenix
	Maricopa County Community College System Office	Phoenix
	Glendale Community College	Glendale
	Maricopa Technical Community College	Phoenix
	Mesa Community College	Mesa
	Phoenix College	Phoenix
	Scottsdale Community College	Scottsdale
	Mohave Community College	Kingman
	Navajo Community College	Tsaile
	Northern Arizona University	Flagstaff
	Northland Pioneer College	Holbrook
	Pima Community College	Tucson
	Southwestern College	Phoenix
	University of Arizona	Tucson
	Yavapai College	Prescott
AR	Arkansas College	Batesville
	Arkansas State University-Main Campus	State University
	Arkansas State University-Beebe Branch	Beebe
	Arkansas Tech University	Russellville
	Central Baptist College	Conway
	College of the Ozarks	Clarksville
	Crowley's Ridge College	Paragould
	Garland County Community College	Hot Springs
	Harding College-Main Campus	Searcy
	Henderson State University	Arkadelphia
	Hendrix College	Conway
	John Brown University	Siloam Springs
	Mississippi County Community College	Blytheville
	Quachita Baptist University	Arkadelphia
	Philander Smith College	Little Rock
	Phillips County Community College	Helena
	Southern Arkansas University	Magnolia
	Southern Arkansas University Southwest Technical Institute	East Camden
	Southern Baptist College	Walnut Ridge
	Southern State College	Magnolia
	University of Arkansas-Main Campus	Fayetteville
	University of Arkansas-Little Rock	Little Rock
	University of Arkansas Medical Sciences Campus	Little Rock
	University of Arkansas-Monticello	Monticello
	Westlark Community College	Fort Smith
CA	Allan Hancock College	Santa Maria
	Ambassador College	Pasadena
	American Baptist Seminary of the West-Central Office	Berkeley
	American Baptist Seminary of the West-Covina	Covina
	Armstrong College	Berkeley
	Azusa Pacific College	Azusa
	Bakersfield College	Bakersfield
	Barstow College	Barstow
	Bauder College	Sacramento
	Bethany Bible College	Santa Cruz
	Biola College	La Mirada
	Brooks College	Long Beach

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Brooks Institute of Santa Barbara	Santa Barbara
	Butte College	Oroville
	Cabrillo College	Aptos
	California Baptist College	Riverside
	California College of Arts and Crafts	Oakland
	California Institute of the Arts	Valencia
	California Institute of Asian Studies	San Francisco
	California Institute of Technology	Pasadena
	California Lutheran College	Thousand Oaks
	California Maritime Academy	Vallejo
	California State College-San Bernadino	San Bernardino
	California State College-Stanislaus	Turlock
	California Polytechnic State University-San Luis Obispo	San Luis Obispo
	California State University-Fresno	Fresno
	California State University-Fullerton	Fullerton
	California State University-Hayward	Hayward
	California State University-Long Beach	Long Beach
	California State University-Los Angeles	Los Angeles
	California State University-Sacramento	Sacramento
	San Diego State University	San Diego
	San Jose State University	San Jose
	Cerritos College	Norwalk
	Cerro Coso Community College	Ridgecrest
	Chapman College	Orange
	Christian Heritage College	El Cajon
	Church Divinity School of the Pacific	Berkeley
	Citrus College	Azusa
	Claremont Colleges-System Office	Claremont
	Claremont Men's College	Claremont
	Claremont University Center and Graduate School	Claremont
	Harvey Mudd College	Claremont
	Pitzer College	Claremont
	Pomona College	Claremont
	Scripps College	Claremont
	Coast Community College-System Office	Costa Mesa
	Golden West College	Huntington Beach
	Orange Coast College	Costa Mesa
	Cogswell College	San Francisco
	Colegio De La Tierra	Goshen
	College of the Canyons	Valencia
	College of the Desert	Palm Desert
	College of Marin	Kentfield
	College of Notre Dame	Belmont
	College of the Redwoods	Eureka
	College of the Siskiyous	Weed
	Columbia Junior College	Columbia
	Compton Community College	Compton
	Contra Costa Community College-System Office	
	Diablo Valley College	Pleasant Hill
	Cuesta College	San Luis Obispo
	Cypress College	Cypress
	Dominican College of San Rafael	San Rafael
	El Camino College	Torrance
	Foothill-De Anza Community College District-System Office	Los Altos Hills
	De Anza College	Cupertino
	Foothill College	Los Altos Hills
	Fuller Theological Seminary	Pasadena
	Gavilan College	Gilroy
	Glendale Community College	Glendale
	Golden Gate University	San Francisco
	Grossmont College	El Cajon
	Hartnell College	Salinas
	Holy Family College	Mission San Jose

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Holy Names College	Oakland
	Immaculate Heart College	Los Angeles
	Indian Valley Colleges	Novato
	John F. Kennedy University	Orinda
	Lake Tahoe Community College	S. Lake Tahoe
	Lassen College	Susanville
	LaVerne College	La Verne
	L.I.F.E. Bible College	Los Angeles
	Lincoln University	San Francisco
	Lone Mountain College	San Francisco
	Long Beach City College	Long Beach
	Los Angeles Baptist College	Newhall
	Los Angeles Community College-System Office	Los Angeles
	East Los Angeles College	Los Angeles
	Los Angeles City College	Los Angeles
	Los Angeles Harbor College	Wilmington
	Los Angeles Mission College	San Fernando
	Los Angeles Pierce College	Woodland Hills
	Los Angeles Southwest College	Los Angeles
	Los Angeles Valley College	Van Nuys
	West Los Angeles College	Culver City
	Los Rios Community College-System Office	Sacramento
	Cosumnes River College	Sacramento
	Sacramento City College	Sacramento
	Loyla Marymount University	Los Angeles
	Marymount Palos Verdes College	Rancho Palos Verdes
	Mendocino College	Ukiah
	Menlo College	Menlo Park
	Mennonite Brethren Biblical Seminary	Fresno
	Merced College	Merced
	Mills College	Oakland
	Monterey Institute for Foreign Studies	Monterey
	Monterey Peninsula College	Monterey
	Mount San Antonio College	Walnut
	Mount San Jacinto College	San Jacinto
	Napa College	Napa
	National University	San Diego
	New College of California	San Francisco
	Northrop University	Inglewood
	Occidental College	Los Angeles
	Ohlone College	Fremont
	Otis Art Institute of Los Angeles County	Los Angeles
	Pacific Christian College	Fullerton
	Pacific College	Fresno
	Pacific Oaks College	Pasadena
	Pacific School of Religion	Berkeley
	Pacific Union College	Angwin
	Palomar College	San Marcos
	Palo Verde College	Blythe
	Pasadena City College	Pasadena
	Patten Bible College	Oakland
	Pepperdine University	Malibu
	Peralta Community Colleges-System Office	Oakland
	College of Alameda	Alameda
	Point Loma College	San Diego
	Porterville College	Porterville
	Rand Graduate Institute of Policy Studies	Santa Monica
	Riverside City College	Riverside
	Rosemead Graduate School of Psychology	Rosemead
	Saddleback Community College	Mission Viejo
	Saint Mary's College of California	Moraga

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Saint Patrick's College	Mountain View
	San Diego Community College-Central Office	San Diego
	San Diego Community College-City College	San Diego
	San Diego Community College-Evening College	
	San Francisco Art Institute	San Francisco
	San Francisco Conservatory of Music	San Francisco
	San Francisco Theological Seminary	San Anselmo
	San Joaquin Delta College	Stockton
	San Jose Community College District-	
	Evergreen Valley College	San Jose
	San Jose City College	San Jose
	San Mateo County Community College District-System Office	San Mateo
	Canada College	Redwood City
	College of San Mateo	San Mateo
	Skyline College	San Bruno
	Santa Ana College	Santa Ana
	Santa Barbara City College	Santa Barbara
	Santa Monica College	Santa Monica
	Santa Rosa Junior College	Santa Rosa
	Shasta College	Redding
	Sierra College	Rocklin
	Simpson College	San Francisco
	Solano Community College	Suisun City
	Southern California College	Costa Mesa
	Southern California College of Optometry	Fullerton
	Southwestern University School of Law	Los Angeles
	Stanford University	Stanford
	State Center Community College District	
	Fresno City College	Fresno
	Reedley College	Reedley
	Taft College	Taft
	United States International University	San Diego
	University of California-Berkeley	Berkeley
	University of California-Davis	Davis
	University of California Hastings College of Law	San Francisco
	University of California-Irvine	Irvine
	University of California-Los Angeles	Los Angeles
	University of California-Riverside	Riverside
	University of California-San Francisco	San Francisco
	University of California-Santa Barbara	Santa Barbara
	University of the Pacific	Stockton
	University of Redlands	Redlands
	University of San Diego	San Diego
	University of San Francisco	San Francisco
	University of Santa Clara	Santa Clara
	University of Southern California	Los Angeles
	University of West Los Angeles	Culver City
	Ventura County Community College District	
	Moorpark College	Moorpark
	Oxnard College	Oxnard
	Ventura College	Ventura
	West Coast Bible College	Fresno
	West Coast University Central Office	Los Angeles
	West Coast University Orange County Center	Orange
	Western State University College of Law-Orange County	Fullerton
	Western State University College of Law-San Diego	San Diego
	West Hills College	Coalinga
	Westmont College	Santa Barbara
	West Valley College	Saratoga

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Whittier College	Whittier
	Woodbury University	Los Angeles
	The Wright Institute	Berkeley
	Yuba College	Marysville
CO	Adams State College	Alamosa
	Aims Community College	Greeley
	Arapahoe Community College	Littleton
	Colorado College	Colorado Springs
	Colorado Mountain College-East Campus	Leadville
	Colorado Mountain College-West Campus	Glenwood Springs
	Colorado School of Mines	Golden
	Colorado State University	Fort Collins
	Colorado Technical College	Manitou Springs
	Colorado Women's College	Denver
	Community College of Denver-Auraria Campus	Denver
	Community College of Denver-North Campus	Denver
	Community College of Denver-Red Rocks Campus	Golden
	Conservative Baptist Theological Seminary	Denver
	El Paso Community College	Colorado Springs
	Fort Lewis College	Durango
	Iliff School of Theology	Denver
	Lamar Community College	Lamar
	Loretto Heights College	Denver
	Mesa College	Grand Junction
	Metropolitan State College	Denver
	Morgan Community College	Fort Morgan
	Northeastern Junior College	Sterling
	Ortero Junior College	La Junta
	Regis College	Denver
	Rockmont College	Denver
	Saint Thomas Seminary	Denver
	Trinidad State Junior College	Trinidad
	University of Colorado-Boulder	Boulder
	University of Colorado-Colorado Springs	Colorado Springs
	University of Colorado-Denver	Denver
	University of Denver	Denver
	University of Denver College of Law	Denver
	University of Northern Colorado	Greeley
	University of Southern Colorado	Pueblo
	Western Bible College	Morrison
	Western State College of Colorado	Gunnison
CT	Albertus Magnus College	New Haven
	Annhurst College	Woodstock
	Bridgeport Engineering Institute	Bridgeport
	Connecticut College	New London
	Eastern Connecticut State College	Willimnatic
	Greater Hartford Community College	Hartford
	Hartford State Technical College	Hartford
	Housatonic Regional Community College	Bridgeport
	Mattuck Community College	Waterbury
	Middlesex Community College	Middletown
	Mitchell College	New London
	Mohegan Community College	Norwich
	Northwestern Connecticut Community College	Winsted
	Norwalk Community College	Norwald
	Post Junior College	Waterbury
	Quinebaug Valley Community College	Danielson
	Saint Joseph College	West Hartford

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Thames Valley State Technical College	Norwich
	Trinity College	Hartford
	Tunxis Community College	Farmington
	University of Bridgeport	Bridgeport
	University of Hartford	West Hartford
	University of New Haven	West Haven
	Yale University	New Haven
DE	Delaware State College	Dover
	Delaware Technical and Community College	Dover
	Goldey Beacom College	Wilmington
	University of Delaware	Newark
	Wesley College	Dover
DC	American University	Washington
	Catholic University of America	Washington
	District of Columbia Teachers College	Washington
	Gallaudet College	Washington
	George Washington University	Washington
	Howard University	Washington
	Mount Vernon College	Washington
	Trinity College	Washington
FL	Barry College	Miami
	Brevard Community College	Cocoa
	Broward Community College	Fort Lauderdale
	Central Florida Community College	Ocala
	Chipola Junior College	Marianna
	College of Boca Raton	Boca Raton
	Daytona Beach Community College	Daytona Beach
	Eckerd College	St. Petersburg
	Edison Community College	Fort Meyers
	Embry-Riddle Aeronautical University	Daytona Beach
	Flagler College	St. Augustine
	Florida A & M University	Tallahassee
	Florida Atlantic University	Boca Raton
	Florida College	Temple Terrace
	Florida International University	Miami
	Florida Junior College	Jacksonville
	Florida Keys Community College	Key West
	Florida Southern College	Lakeland
	Florida Technological University	Orlando
	Fort Lauderdale College	Fort Lauderdale
	Gulf Coast Community College	Panama City
	Heed University	Hollywood
	Hillsborough Community College	Tampa
	Indian River Community College	Fort Pierce
	Jacksonville University	Jacksonville
	Jones College	Jacksonville
	Lake City Community College	Lake City
	Lake-Sumter Community College	Leesburg
	Manatee Junior College	Bradenton
	Miami Christian College	Miami
	Miami-Dade Community College	Miami
	North Florida Junior College	Madison
	Nova University	Fort Lauderdale
	Okaloosa-Walton Junior College	Niceville
	Palm Beach Atlantic College	West Palm Beach
	Palm Beach Junior College	Lake Worth
	Pensacola Junior College	Pensacola
	Polk Community College	Winter Haven

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Rollins College	Winter Park
	Saint Johns River Junior College	Palatka
	Saint Leo College	Saint Leo
	Santa Fe Community College	Gainesville
	Seminole Community College	Sanford
	South-Eastern Bible College	Lakeland
	South Florida Junior College	Avon Park
	University of Florida	Gainesville
	University of Miami	Coral Gables
	University of North Florida	Jacksonville
	Warner Southern College	Lake Wales
	Webber College	Babson Park
GA	Abraham Baldwin Agricultural College	Tifton
	Agnes Scott College	Decatur
	Albany Area Vocational Technical School	Albany
	Albany Junior College	Albany
	Albany State College	Albany
	Andrew College	Cuthbert
	Armstrong State College	Savannah
	Atlanta Christian College	East Point
	Atlanta Junior College	Atlanta
	Atlanta University	Atlanta
	Augusta College	Augusta
	Bainbridge Junior College	Bainbridge
	Berry College	Mount Berry
	Brenau College	Gainesville
	Brewton-Parker College	Mount Vernon
	Carroll County Area Vocational-Technical School	Carrollton
	Carver Bible Institute and College	Atlanta
	Clark College	Atlanta
	Clayton Junior College	Morrow
	Columbus College	Columbus
	Dalton Junior College	Dalton
	DeKalb Community College	Clarkston
	Emanuel County Junior College	Swainsboro
	Emory University	Atlanta
	Fort Valley State College	Fort Valley
	Gainesville Junior College	Gainesville
	Georgia College	Milledgeville
	Georgia Institute of Technology	Atlanta
	Georgia Military College	Milledgeville
	Georgia Southern College	Statesboro
	Georgia Southwestern College	Americus
	Georgia State University	Atlanta
	Gordon Junior College	Barnesville
	Kennesaw Junior College	Marietta
	LaGrange College	LaGrange
	Macon Junior College	Macon
	Marietta-Cobb Area Vocational Technical School	Marietta
	Mercer University	Macon
	Mercer University in Atlanta	Atlanta
	Middle Georgia College	Cochran
	Morehouse College	Atlanta
	Moultrie Area Vocational-Technical School	Moultrie
	North Georgia College	Dahlonega
	North Georgia Technical and Vocational School	Clarkesville
	Oglethorpe College	Atlanta
	Pickens Area Vocational-Technical School	Jasper
	Piedmont College	Demorest
	Reinhardt College	Waleska

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Savannah Area Vocational Technical School	Savannah
	Savannah State College	Savannah
	Shorter College	Rome
	South Georgia College	Douglas
	South Georgia Technical and Vocational School	Americus
	Southern Technical Institute	Marietta
	Swainsboro Area Vocational-Technical School	Swainsboro
	Thomas Area Vocational-Technical School	Thomasville
	Tift College	Forsyth
	Toccoa Falls College	Toccoa Falls
	Troup County Area Vocational Technical School	LaGrange
	Truett McConnell College	Cleveland
	University of Georgia	Athens
	Upson County Area Vocational-Technical School	Thomaston
	Valdosta State College	Valdosta
	Valdosta Technical School	Valdosta
	Walker County Area Technical School	Rock Spring
	Waycross-Ware Area Technical School	Waycross
	Wesleyan College	Macon
	West Georgia College	Carrollton
	Young Harris College	Young Harris
HI	Brigham Young University-Hawaii Campus	Laie Oahu
	Chaminade College of Honolulu	Honolulu
	Hawaii Pacific College	Honolulu
	University of Hawaii-Honolulu Community College	Honolulu
	University of Hawaii-Kapiolani Community College	Honolulu
	University of Hawaii-Kauai Community College	Lihue
	University of Hawaii-Leeward Community College	Pearl City
	University of Hawaii-Manoa	Honolulu
	University of Hawaii-Maui Community College	Kahului
	University of Hawaii-Windward Community College	Kaneohe
ID	Boise State University	Boise
	College of Southern Idaho	Twin Falls
	Idaho State University	Pocatello
	North Idaho College	Coeur D'Alene
	Northwest Nazarene College	Nampa
	Ricks College	Rexburg
	University of Idaho	Moscow
IL	Augustana College	Rock Island
	Aurora College	Aurora
	Barat College	Lake Forest
	Belleville Area College	Belleville
	Blackburn College	Carlinville
	Black Hawk College	Moline
	Bradley University	Peoria
	Carl Sandburg College	Galesburg
	Central YMCA Community College	Chicago
	Chicago College of Osteopathic Medicine	Chicago
	Chicago State University	Chicago
	College of DuPage	Glen Ellyn

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	College of Lake County	Grayslake
	College of St. Francis	Joliet
	College of the University of Chicago	Chicago
	Danville Junior College	Danville
	DeLourdes College	Des Plaines
	DePaul University	Chicago
	DeVry Institute of Technology	Chicago
	Eastern Illinois University	Charleston
	Elgin Community College	Elgin
	Elmhurst College	Elmhurst
	Eureka College	Eureka
	George Williams College	Downers Grove
	Governors State University	Park Forest South
	Greenville College	Greenville
	Highland Community College	Freeport
	Illinois Benedictine College	Lisle
	Illinois Central College	East Peoria
	Illinois College	Jacksonville
	Illinois College of Optometry	Chicago
	Illinois College of Podiatric Medicine	Chicago
	Illinois Institute of Technology	Chicago
	Illinois State University	Normal
	Illinois Valley Community College	Oglesby
	Illinois Wesleyan University	Bloomington
	Joliet Junior College	Joliet
	Judson College	Elgin
	Kankakee Community College	Kankakee
	Kendall College	Evanston
	Kishwaukee College	Malta
	Knox College	Galesburg
	Lake Forest College	Evanston
	Lakeland College	Mattoon
	Lewis and Clark Community College	Godfrey
	Lincoln Trail College	Robinson
	Logan (John A.) College	Carterville
	Loyola University of Chicago	Chicago
	MacMurray College	Jacksonville
	McHenry County College	Crystal Lake
	McKendree College	Lebanon
	Meadville Theological School	Lombard
	Millikin University	Decatur
	Moraine Valley Community College	Palos Hills
	National College of Chiropractic	Lombard
	North Central College	Naperville
	Northeastern Illinois University	Chicago
	Northern Baptist Theological Seminary	Lombard
	Northern Illinois University	DeKalb
	Northwestern University	Evanston
	Oakton Community College	Morton Grove
	Olivet Nazarene College	Kankakee
	Olney Central College	Mt. Carmel
	Prairie State Community College	Chicago Heights
	Rockford College	Rockford
	Rock Valley College	Rockford
	Roosevelt University	Chicago
	Rush University, College of Nursing and Allied Health Sciences	Chicago
	Rush University, Rush Medical College	Chicago
	Sangamon State University	Springfield
	Sauk Valley College	Dixon
	Southern Illinois University	Carbondale
	Southern Illinois University	Edwardsville
	Spertus College of Judaica	Chicago
	Spoon River College	Canton
	Springfield College in Illinois	Springfield

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	State Community College of East Saint Louis, Illinois	East St. Louis
	Thornton Community College	South Holland
	Triton College	River Grove
	University of Health Sciences, The Chicago Medical School	Chicago
	University of Illinois at Chicago Circle	Chicago
	University of Illinois at the Medical Center, School of Public Health	Chicago
	University of Illinois at Urbana-Champaign	Urbana-Champaign
	Wabash Valley College	Mt. Carmel
	Waubonsee Community College	Sugar Grove
	Western Illinois University	Macomb
	Wheaton College	Wheaton
	William Rainey Harper College	Palatine
IN	Anderson College	Anderson
	Associated Mennonite Biblical Seminary	Elkhart
	Ball State University	Muncie
	Bethel College	Mishawaka
	Butler University	Indianapolis
	DePauw University	Greencastle
	Earlham College	Richmond
	Franklin College	Franklin
	Goshen College	Goshen
	Grace College	Winona Lake
	Hanover College	Hanover
	Holy Cross Junior College	Notre Dame
	Huntington College	Huntington
	Indiana Central College	Indianapolis
	Indiana Institute of Technology	Fort Wayne
	Indiana State University	Evansville
	Indiana University	Bloomington
	Indiana University-East	Richmond
	Indiana University-Kokomo	Kokomo
	Indiana University-Northwest	Gary
	Indiana University-South Bend	South Bend
	Indiana University-Southeast	New Albany
	Indiana University-Purdue University at Fort Wayne	Fort Wayne
	Indiana Vocational Technical College	Indianapolis
	International Junior College	Fort Wayne
	Manchester College	North Manchester
	Marian College	Indianapolis
	Marion College	Marion
	Oakland College	Oakland City
	Purdue State University	Muncie
	Purdue University	West Lafayette
	Purdue University-Calumet	Calumet
	Purdue University-North Central	Westville
	Rose-Hulman Institute of Technology	Terre Haute
	Saint Joseph's College	Rensselaer
	Saint Mary's College	Notre Dame
	Saint Mary of the Woods College	Saint Mary of the Woods
	Saint Meinard College	St. Meinard
	Taylor University	Upland
	Tri-State University	Angola
	University of Evansville	Evansville
	University of Notre Dame	South Bend
	Valparaiso University	Valparaiso
	Vincennes University	Vincennes
	Wabash College	Crawfordsville

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
IA	Area One Vocational-Technical School	Calmar and Dubuque
	Briar Cliff College	Sioux City
	Central College	Pella
	Clarke College	Dubuque
	Coe College	Cedar Rapids
	Cornell College	Mt. Vernon
	Des Moines Area Community College	Ankeny
	Drake University	Des Moines
	Ellsworth Community College	Iowa Falls
	Grinnell College	Grinnell
	Hawkeye Institute of Technology	Waterloo
	Iowa Central Community College	Fort Dodge
	Iowa Lakes Community College	Estherville
	Iowa State University	Ames
	Iowa Wesleyan College	Mount Pleasant
	Iowa Western Community College	Council Bluffs
	Kirkwood Community College	Cedar Rapids
	Loras College	Dubuque
	Luther College	Decorah
	Marshalltown Community College	Marshalltown
	Marycrest College	Davenport
	Morningside College	Sioux City
	Mount Mercy College	Cedar Rapids
	North Iowa Area Community College	Mason City
	Open Bible College	Des Moines
	Palmer College of Chiropractic	Davenport
	Simpson College	Indianola
	Southeastern Community College	Burlington
	Southwestern Community College	Creston
	University of Dubuque	Dubuque
	University of Dubuque Theological Seminary	Dubuque
	University of Iowa	Iowa City
	University of Northern Iowa	Cedar Falls
	Upper Iowa University	Fayette
	Wartburg College	Waverly
	Wartburg Seminary	Dubuque
	Westmar College	LeMars
	Western Iowa Technical Community College	Sioux City
KS	Allen County Community Junior College	Iola
	Baker University	Baldwin
	Barton County Community College	Great Bend
	Benedictine College	Atchison
	Bethel College	North Newton
	Central College	McPherson
	Cloud County Community College	Concordia
	Coffeyville Community Junior College	Coffeyville
	Colby Community College	Colby
	Cowley County Community College	Arkansas City
	Dodge City Community College	Dodge City
	Donnelly College	Kansas City
	Emporia Kansas State College	Emporia
	Fort Hays Kansas State College	Hays
	Fort Scott Community College	Fort Scott
	Friends Bible College	Haviland
	Garden City Community College	Garden City
	Haskell Indian Junior College	Lawrence
	Hesston College	Hesston
	Highland Community Junior College	Highland
	Hutchinson Community Junior College	Hutchinson
	Independence Community Junior College	Independence
	Johnson County Community College	Overland Park
	Kansas City Community College	Kansas City

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Kansas Newman College	Wichita
	Kansas State College of Pittsburg	Pittsburg
	Kansas State University	Manhattan
	Kansas Technical Institute	Salina
	Kansas Wesleyan	Salina
	Labette Community Junior College	Parsons
	Manhattan Christian College	Manhattan
	Marymount College of Kansas	Salina
	McPherson College	McPherson
	Mid-America Nazarene College	Olathe
	Neosho County Community Junior College	Chanute
	Ottawa University	Ottawa
	Pratt Community College	Pratt
	Saint John's College	Winfield
	Saint Mary College	Leavenworth
	Saint Mary of the Plains College	Dodge City
	Seward County Community College	Liberal
	Southwestern College in Kansas	Winfield
	Sterling College	Sterling
	Tabor College	Hillsboro
	The University of Kansas	Lawrence
	Washburn University of Topeka	Topeka
	Wichita State University	Wichita
KY	Alice Lloyd College	Pippa Passes
	Asbury College	Wilmore
	Bellarmine College	Louisville
	Berea College	Berea
	Brescia College	Owensboro
	Campbellsville College	Campbellsville
	Centre College of Kentucky	Danville
	Cumberland College	Williamsburg
	Eastern Kentucky University	Richmond
	Georgetown College	Georgetown
	Jefferson Vocational Regional Office	Jeffersontown
	Kentucky Christian College	Grayson
	Kentucky State University	Frankfort
	Kentucky Wesleyan College	Owensboro
	Lees Junior College	Jackson
	Lindsey Wilson College	Columbia
	Midway College	Midway
	Morehead State University	Morehead
	Murray State University	Murray
	Pikeville College	Pikeville
	Saint Catharine College	Saint Catharine
	Southeastern Christian College	Winchester
	Sue Bennett College	London
	Thomas More College	Fort Mitchell
	Transylvania University	Lexington
	University of Kentucky	Lexington
	University of Kentucky Community College System	Lexington
	University of Louisville	Louisville
	Western Kentucky University	Bowling Green
LA	Bossier Parish Community College	Bossier City
	Centenary College of Louisiana	Shreveport
	Delgado College	New Orleans
	Dillard University	New Orleans
	Grambling State University	Grambling
	Louisiana State University-Central Office	Baton Rouge

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Louisiana State University and Agricultural and Mechanical College at Baton Rouge	Baton Rouge
	Louisiana State University-Alexandria	Alexandria
	Louisiana State University-Eunice	Eunice
	Louisiana State University-Shreveport	Shreveport
	University of New Orleans	New Orleans
	Louisiana Tech University	Ruston
	McNeese State University	Lake Charles
	New Orleans Baptist Theological Seminary	New Orleans
	Northeast Louisiana University	Monroe
	Northwestern State University of Louisiana	Natchitoches
	Notre Dame Seminary School of Theology	New Orleans
	Our Lady of Holy Cross College	New Orleans
	Saint Bernard Parish Community College	Chalmette
	Saint Joseph Seminary College	Saint Benedict
	Saint Mary's Dominican College	New Orleans
	Southern University in New Orleans	New Orleans
	Tulane University of Louisiana	New Orleans
	Xavier University of Louisiana	New Orleans
ME	Bowdoin College	Brunswick
	Colby College	Waterville
	College of the Atlantic	Bar Harbor
	Eastern Maine Vocational and Technical Institute	Bangor
	Maine Maritime Academy	Castine
	Masson College	Springvale
	South Maine Vocational and Technical Institute	South Portland
	Unity College	Unity
	University of Maine at Orono	Orono
MD	Bowie State College	Bowie
	Catonsville Community College	Catonsville
	Charles County Community College	La Plata
	Chesapeake College	Wye Mills
	Columbia Union College	Takoma Park
	Community College of Baltimore	Baltimore
	Dundalk Community College	Baltimore
	Essex Community College	Baltimore County
	Garrett Community College	McHenry
	Goucher College	Towson
	Hagerstown Junior College	Hagerstown
	Harford Community College	Bel Air
	Hood College	Frederick
	Howard Community College	Columbia
	Johns Hopkins University	Baltimore
	Loyola College	Baltimore
	Montgomery College	Rockville
	Saint John's College	Annapolis
	Saint Mary's College of Maryland	Saint Mary's City
	Towson State College	Baltimore
	University of Baltimore	Baltimore
	University of Maryland	College Park
	Villa Julie College	Stevenson
	Washington College	Chestertown

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
MA	Amherst College	Amherst
	Anna Maria College	Paxton
	Assumption College	Worcester
	Bay Path Junior College	Longmeadow
	Bentley College	Waltham
	Boston College	Chestnut Hill
	Boston University	Boston
	Gordon College	Wenham
	Hampshire College	Amherst
	Harvard University	Cambridge
	Lasell Junior College	Auburndale
	Lesley College	Cambridge
	Massachusetts Institute of Technology	Cambridge
	Merrimack College	North Andover
	Mount Holyoke College	South Hadley
	Nichols College	Dudley
	Northeastern University	Boston
	Regis College	Weston
	Simon's Rock	Great Barrington
	Smith College	Northampton
	Southeastern Massachusetts University	North Darmouth
	Springfield College	Springfield
	Springfield Technical Community College	Springfield
	Stonehill College	North Easton
	Suffolk University	Boston
	Tufts University	Medford
	University of Massachusetts	Boston
	Wentworth Institute	Boston
	Wheelock College	Boston
	Williams College	Williamstown
	Worcester Junior College	Worcester
	Worcester Polytechnic Institute	Worcester
MI	Alma College	Alma
	Alpena Community College	Alpena
	Andrews University	Berrien Springs
	Aquinas College	Grand Rapids
	Bay de Noc Community College	Escanaba
	Calvin College	Grand Rapids
	Calvin Theological Seminary	Grand Rapids
	Central Michigan University	Mount Pleasant
	Concordia Lutheran Junior College	Ann Arbor
	Delta College	University Center
	Detroit Institute of Technology	Detroit
	Eastern Michigan University	Ypsilanti
	Ferris State College	Big Rapids
	General Motors Institute	Flint
	Grace Bible College	Wyoming
	Grand Rapids Baptist College	Grand Rapids
	Grand Rapids Junior College	Grand Rapids
	Grand Valley State College	Allendale
	Highland Park Community College	Highland Park
	Hillsdale College	Hillsdale
	Hope College	Holland

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Jackson Community College	Jackson
	Kalamazoo College	Kalamazoo
	Kalamazoo Valley Community College	Kalamazoo
	Kirtland Community College	Roscommon
	Lake Michigan College	Benton Harbor
	Lake Superior State College	Saulte Ste. Marie
	Lansing Community College	Lansing
	Macomb County Community College	Warren
	Madonna College	Livonia
	Marygrove College	Detroit
	Mercy College of Detroit	Detroit
	Merrill-Palmer Institute	Detroit
	Michigan Department of Education-Environmental Guidelines	Lansing
	Michigan State University	East Lansing
	Michigan Technological University	Houghton
	Mid Michigan Community College	Harrison
	Monroe County Community College	Monroe
	Montcalm Community College	Sidney
	Mott Community College	Flint
	Muskegon Business College	Muskegon
	Muskegon Community College	Muskegon
	Northern Michigan University	Marquette
	Northwestern Michigan College	Traverse City
	Oakland Community College	Bloomfield Hills
	Oakland University	Rochester
	Olivet College	Olivet
	Saginaw Valley State College	University Center
	Saint Mary's College	Orchard Lake
	Schoolcraft College	Livonia
	Shaw College at Detroit	Detroit
	Southwestern Michigan College	Dowagiac
	Spring Arbor College	Spring Arbor
	Suomi College	Hancock
	University of Detroit	Detroit
	University of Michigan	Ann Arbor
	Walsh College	Troy
	Washtenaw Community College	Ann Arbor
	Wayne County Community College	Detroit
	Wayne State University	Detroit
	Western Michigan University	Kalamazoo
	West Shore Community College	Scottville
	Western Theological Seminary	Holland
MN	Anoka-Ramsey Community College	Coon Rapids
	Augsburg College	Minneapolis
	Austin Community College	Austin
	Bemidji State University	Bemidji
	Bethany Lutheran College	Mankato
	Brainerd Community College	Brainerd
	Carleton College	Northfield
	College of Saint Benedict	St. Joseph
	College of St. Catherine	St. Paul
	College of St. Scholastica	Duluth
	College of St. Thomas	St. Paul
	Concordia College	Moorhead
	Crosier Seminary Junior College	Onamia
	Dr. Martin Luther College	New Ulm
	Fergus Falls Community College	Fergus Falls
	Hibbing Community College	Hibbing
	Itasca Community College	Grand Rapids
	Lakewood Community College	White Bear Lake
	Luther Theological Seminary	St. Paul
	Macalester College	St. Paul
	Mankato State University	Mankato

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Mesabi Community College	Virginia
	Metropolitan Community College	Minneapolis
	Metropolitan State University	St. Paul
	Minneapolis College of Art and Design	Minneapolis
	Minnesota Bible College	Rochester
	Moorhead State College	Moorhead
	Normandale Community College	Bloomington
	North Hennepin Community College	Minneapolis
	Northland Community College	Thief River Falls
	Northwestern College	Roseville
	Rainy River Community College	International Falls
	Rochester Community College	Rochester
	Saint John's University	Collegeville
	Saint Mary's College	Winona
	Southwest Minnesota State College	Marshall
	St. Cloud Area Vocational Technical Institute	St. Cloud
	St. Cloud State University	St. Cloud
	St. Mary's Junior College	Minneapolis
	St. Paul Bible College	Bible College
	United Theological Seminary of the Twin Cities	New Brighton
	University of Minnesota	Minneapolis
	Vermilion Community College	Ely
	William Mitchell College of Law	St. Paul
	Winona State University	Winona
	Worthington Community College	Worthington
MS	Alcorn State University	Lorman
	Belhaven College	Jackson
	Clarke College	Newton
	Coahama Junior College	Clarksdale
	Copiah-Lincoln Junior College	Wesson
	Delta State University	Cleveland
	East Central Junior College	Decatur
	East Mississippi Junior College	Scooba
	Hinds Junior College	Raymond
	Holmes Junior College	Goodman
	Itawamba Junior College	Fulton
	Jackson State University	Jackson
	John C. Stennis Vocational Complex	Dekalb
	Jones County Junior College	Ellisville
	Mary Holmes College	West Point
	Meridian Junior College	Meridian
	Millsaps College	Jackson
	Mississippi College	Clinton
	Mississippi Delta Junior College	Moorhead
	Mississippi Gulf Coast Junior College	Perkinston
	Mississippi Industrial College	Holly Springs
	Mississippi State University	Mississippi State
	Mississippi University for Women	Columbus
	Northeast Mississippi Junior College	Booneville
	Northwest Mississippi Junior College	Senatobia
	Pearl River Junior College	Poplarville
	Rust College	Holly Springs
	Southwest Mississippi Junior College	Summit
	Tougaloo College	Tougaloo
	University of Mississippi	University
	University of Mississippi Medical Center	Jackson
	University of Southern Mississippi	Hattiesburg
	Utica Junior College	Utica
	Wesley College	Florence
	William Carey College	Hattiesburg
	Wood Junior College	Mathiston

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
MO	Assemblies of God Graduate School	Springfield
	Avila College	Kansas City
	Calvary Bible College	Kansas City
	Central Bible College	Springfield
	Central Methodist College	Fayette
	Central Missouri State University	Warrensburg
	Columbia College	Columbia
	Concordia Seminary	St. Louis
	Cottey College	Nevada
	Crowder College	Neosho
	Culver-Stockton College	Canton
	Fontbonne College	St. Louis
	Hannibal Lagrange College	Hannibal
	Harris Teachers College	St. Louis
	Jefferson College	Hillsboro
	Kansas City Art Institute	Kansas City
	Kansas City College of Osteopathic Medicine	Kansas City
	Logan College of Chiropractic	Chesterfield
	Longview Community College	Kansas City
	Maple Woods Community College	Kansas City
	Maryville College	St. Louis
	Meramec Community College	St. Louis
	Missouri Baptist College	St. Louis
	Missouri Southern State College	Joplin
	Moberly Area Junior College	Moberly
	Northeast Missouri State University	Kirksville
	Northwest Missouri State University	Maryville
	Rockhurst College	Kansas City
	Saint Louis College of Pharmacy	St. Louis
	Saint Louis Community College at Forest Park	St. Louis
	Saint Louis University	St. Louis
	Saint Paul's College	Concordia
	School of the Ozarks	Point Lookout
	Southwest Missouri State University	Springfield
	State Fair Community College	Sedalia
	Stephen's College	Columbia
	Tarkio College	Tarkio
	The Principia	St. Louis
	Three Rivers Community College	Poplar Bluff
	University of Missouri-Columbia	Columbia
	University of Missouri-Kansas City	Kansas City
	University of Missouri-Rolla	Rolla
	University of Missouri-St. Louis	St. Louis
	Washington University	St. Louis
	Water and Wastewater Technical School	Neosho
	Webster College	Webster
	Westminster College	Fulton
	William Jewell College	Kansas City
MT	Carroll College	Helena
	College of Great Falls	Great Falls
	Dawson College	Glendive
	Eastern Montana College	Billings
	Flathead Valley Community College	Kalispell
	Miles Community College	Miles City
	Montana College of Mineral Science and Technology	Butte
	Montana State University	Bozeman
	Northern Montana College	Havre
	Rocky Mountain College	Billings
	University of Montana	Missoula
	Western Montana College	Dillon

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
NE	Central Technical Community College	Hastings
	Chadron State College	Chadron
	College of Saint Mary	Omaha
	Concordia College	Seward
	Creighton University	Omaha
	Dana College	Blair
	Doane College	Crete
	Grace College of the Bible	Omaha
	Hastings College	Hastings
	Kearney State College	Kearney
	McCook Community College	McCook
	Midland Lutheran College	Fremont
	Mid-Plains Community College	North Platte
	Northeast Technical Community College	Norfolk
	Platte Technical Community College	Columbus
	Southeast Community College	Lincoln
	Union College	Lincoln
	University of Mid-America	Lincoln
	University of Nebraska	Lincoln
	Wayne State College	Wayne
NV	University of Nevada-Las Vegas	Las Vegas
	University of Nevada-Reno	Reno
	Clark County Community College	Las Vegas
	Northern Nevada Community College	Elko
	Sierra Nevada College	Incline Village
	Western Nevada Community College	Carson City
NH	Colby-Sawyer College	New London
	Dartmouth College	Hanover
	Franklin Pierce College	Rindge
	New England College	Henniker
	NH Technical Institute	Concord
	NH Voc-Tech College of Berlin	Berlin
	NH Voc-Tech College of Claremont	Claremont
	NH Voc-Tech College of Laconia	Laconia
	NH Voc-Tech College of Manchester	Manchester
	NH Voc-Tech College of Nashua	Nashua
	NH Voc-Tech College of Portsmouth	Portsmouth
	Saint Anselm's College	Manchester
	University of New Hampshire	Durham
	White Pines College	Chester
NJ	Atlantic Community College	Mays Landing
	Bergen Community College	Paramus
	Brookdale Community College	Lincroft
	Burlington County College	Penberton
	Camden County College	Caldwell
	Centenary College for Women	Hackettstown
	County College of Morris	Dover
	Cumberland County College	Vineland
	Drew University	Madison
	Fairleigh Dickinson University	Rutherford
	Gloucester County College	Sewell
	Kean College of New Jersey	Union
	Mercer County Community College	Trenton
	Middlesex County College	Edison
	Montclair State College	Upper Montclair
	New Jersey Institute of Technology	Newark
	Ocean County College	Toms River
	Passaic County Community College	Paterson
	Princeton University	Princeton

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Rider College	Trenton
	Rutgers the State University	New Brunswick
	Stevens Institute of Technology	Hoboken
	Trenton State College	Trenton
	Union College	Cranford
	Union County Technical Institute	Scotch Plains
	William Paterson College	Wayne
NM	College of the Southwest	Hobbs
	Eastern New Mexico University-Main Campus	Portales
	Eastern New Mexico University-Roswell	Roswell
	New Mexico Highlands University	Las Vegas
	New Mexico Institute of Mining and Technology	Socorro
	New Mexico Junior College	Hobbs
	New Mexico Military Institute	Roswell
	New Mexico State University-Las Cruces	Las Cruces
	New Mexico State University-San Juan	San Juan
	University of Albuquerque	Albuquerque
	University of New Mexico-Main Campus	Albuquerque
NY	Adelphi University	Garden City
	Albany College Pharmacy	Albany
	Albany Law School	Albany
	Alfred University	Alfred
	Bard College	Annandale-on-Hudson
	Bronx Community College	Bronx
	Brooklyn Law School	Brooklyn
	Canisius	Buffalo
	City University of New York	New York
	Clarkson College of Technology	Potsdam
	Colgate University	Hamilton
	College of Mt. Saint Vincent	Riverdale
	College of Saint Rose	Albany
	Columbia University	New York
	Concordia College	Bronxfille
	Cornell University	Ithaca
	Dowling College	Oakdale Long Island
	D'Youville College	Buffalo
	Erie Community College	Buffalo
	Hamilton College	Clinton
	Hartwick College	Oneonta
	Hilbert College	Hamburg
	Hobart-William Smith Colleges	Geneva
	Hofstra University	Hempstead
	Houghton College	Houghton
	Hudson Valley Community College	Troy
	Hunter College	New York
	Ithaca College	Ithaca
	King's College	Briarcliff Manor
	Long Island University	Greenvale
	Manhattan College	Bronx
	Medaille College	Buffalo
	Mercy College	Dobbs Ferry
	Molloy College	Rockville Centre
	New School for Social Research	New York
	New York Institute of Technology	Old Westbury
	New York Law School	New York
	Niagara University	Niagara University

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Paul Smith's College of Arts & Science	Paul Smiths
	Polytechnic Institute of New York	Brooklyn
	Rensselaer Polytechnic Institute	Troy
	Roberts Wesleyan College	Rochester
	Rochester Institute of Technology	Rochester
	Rockefeller University	New York
	Saint Banaventure University	Saint Bonaventure
	Saint John Fisher College	Rochester
	Saint John's University	Jamaica
	Saint Lawrence University	Canton
	Saint Thomas Aquinas College	Sparkhill
	Skidmore College	Saratoga Springs
	Southampton College	Southampton
	State University of New York at Buffalo	Buffalo
	Syracuse University	Syracuse
	The Cooper Union	New York
	Trocaire College	Buffalo
	Ulster County Community College	Stone Ridge
	University of Rochester	Rochester
	Vassar College	Poughkeepsie
	Wagner College	Staten Island
	Webb Institute of Naval Architecture	Glen Cove
	Westchester Community College	Valhalla
NC	Anson Technical Institute	Ansonville
	Appalachian State University	Boone
	Asheville Buncombe Technical Institute	Asheville
	Atlantic Christian College	Wilson
	Beaufort County Technical Institute	Washington
	Belmont Abbey College	Belmont
	Bennett College	Greensboro
	Bladen Technical Institute	Dublin
	Blue Ridge Technical Institute	Flat Rock
	Brevard College	Brevard
	Campbell College	Buies Creek
	Cape Fear Technical Institute	Wilmington
	Carteret Technical Institute	Morehead City
	Catawba College	Salisbury
	Catawba Valley Technical Institute	Hickory
	Central Carolina Technical Institute	Sanford
	Central Piedmont Community College	Charlotte
	Chowan College	Murfreesboro
	Cleveland County Technical Institute	Shelby
	Coastal Carolina Community College	Jacksonville
	College of the Albemarle	Elizabeth City
	Craven Community College	New Bern
	Davidson College	Davidson
	Davidson County Community College	Lexington
	Duke University	Durham
	Durham College	Durham
	East Carolina University	Greenville
	Elon College	Elon College
	Fayetteville State University	Fayetteville
	Fayetteville Technical Institute	Fayetteville
	Gardner Webb College	Boiling Springs
	Gaston College	Dallas
	Greensboro College	Greensboro
	Guilford College	Greensboro
	Guilford Technical Institute	Jamestown
	Halifax Community College	Weldon
	Haywood Technical Institute	Clyde
	High Point College	High Point
	Isothermal Community College	Spindale
	James Sprunt Institute	Kenansville
	Johnson C. Smith University	Charlotte

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Johnston Technical Institute	Smithfield
	Lees-McCrae College	Banner Elk
	Lenoir Community College	Kinston
	Lenoir-Rhyne College	Hickory
	Livingstone College	Salisbury
	Louisburg College	Louisburg
	Mars Hill College	Mars Hill
	Martin Community College	Williamston
	Mayland Technical Institute	Spruce Pine
	McDowell Technical Institute	Marion
	Meredith College	Raleigh
	Methodist College	Fayetteville
	Montreat-Anderson College	Montreat
	Mount Olive College	Mount Olive
	Nash Technical Institute	Rocky Mount
	North Carolina Agricultural and Technical State University	Greensboro
	North Carolina Central University	Durham
	North Carolina State University	Raleigh
	North Carolina Wesleyan College	Rocky Mount
	Pembroke State University	Pembroke
	Pfeiffer College	Misenheimer
	Piedmont Bible College	Winston-Salem
	Piedmont Technical Institute	Roxboro
	Pitt Technical Institute	Greenville
	Queens College	Charlotte
	Randolph Technical Institute	Asheboro
	Richmond Technical Institute	Hamlet
	Roanoke-Chowan Technical Institute	Ahoskie
	Robeson Technical Institute	Lumberton
	Rockingham Community College	Wentworth
	Rowan Technical Institute	Salisbury
	Saint Andrews Presbyterian College	Laurinburg
	Saint Augustine's College	Raleigh
	Saint Mary's College	Raleigh
	Salem College	Winston-Salem
	Sampson Technical Institute	Clinton
	Sandhills Community College	Carthage
	Shaw University	Raleigh
	Stanly Technical Institute	Albermarle
	Surry Community College	Dobson
	Technical Institute of Alamance	Burlington
	Tri-County Technical Institute	Murphy
	University of North Carolina at Chapel Hill	Chapel Hill
	University of North Carolina at Charlotte	Charlotte
	University of North Carolina at Greensboro	Greensboro
	University of North Carolina at Wilmington	Wilmington
	Wake Forest University	Winston-Salem
	Wake Technical Institute	Raleigh
	Warren Wilson College	Swannanoa
	Wayne Community College	Goldsboro
	Western Carolina University	Cullowhee
	Western Piedmont Community College	Morganton
	Wilkes Community College	Wilkesboro
	Wilson County Technical Institute	Wilson
	Wingate College	Wingate
	Winston-Salem State University	Winston-Salem

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
ND	Bismarck Junior College	Bismarck
	Dickinson State College	Dickinson
	Jamestown College	Jamestown
	Lake Region Junior College	Devils Lake
	Mary College	Bismarck
	Mayville State College	Mayville
	Minot State College	Minot
	North Dakota State School of Science	Wahpeton
	North Dakota State University-Main Campus	Fargo
	North Dakota State University-Bottineau	Bottineau
	Trinity Bible Institute	Ellendale
	University of North Dakota-Main Campus	Grand Forks
	University of North Dakota-Williston	Williston
OH	Antioch College	Yellow Springs
	Art Academy of Cincinnati	Cincinnati
	Bluffton College	Bluffton
	Capital University	Columbus
	Case Western Reserve University	Cleveland
	Central Ohio Technical College	Newark
	Central State University	Wilberforce
	Cincinnati Bible College	Cincinnati
	Cincinnati Technical College	Cincinnati
	Clark Technical College	Springfield
	Cleveland Institute of Art	Cleveland
	Cleveland Institute of Music	Cleveland
	Cleveland State University	Cleveland
	College of Mount St. Joseph on the Ohio	Cincinnati
	College of Steubenville	Steubenville
	College of Wooster	Wooster
	Columbus College of Art and Design	Columbus
	Columbus Technical Institute	Columbus
	Cuyahoga Community College	Cleveland
	Davis Junior College	Toledo
	Defiance College	Defiance
	Denison University	Granville
	Franklin University	Columbus
	Hebrew Union College	Cincinnati
	Heidelberg College	Tiffin
	Hiram College	Hiram
	Hocking Technical College	Nelsonville
	Jefferson County Technical Institute	Steubenville
	John Carroll University	Cleveland
	Josephinum College of Liberal Arts	Worthington
	Kent State University	Kent
	Kenyon College	Gambier
	Kettering College of Medical Arts	Kettering
	Lakeland Community College	Mentor
	Lima Technical College	Lima
	Lorain County Community College	Elyria
	Lutheran Theological Seminary	Columbus
	Malone College	Canton
	Marietta College	Marietta
	Marion Technical College	Marion
	Medical College of Ohio	Toledo
	Miami-Jacobs Junior College	Dayton
	Miami University	Oxford
	Mount Union College	Alliance
	Mount Vernon Nazarene College	Mount Vernon
	Muskingum Area Technical College	Zanesville
	Muskingum College	New Concord
	National Training and Operational Technology Center (EPA)	Cincinnati
	North Central Technical College	Mansfield

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Northwest Technical College	Archbold
	Notre Dame College	Cleveland
	Oberlin College	Oberlin
	Ohio Board of Regents-Technical Education Offerings	Columbus
	Ohio Dominican College	Columbus
	Ohio Northern University	Ada
	Ohio State University	Columbus
	Ohio University	Athens
	Ohio Wesleyan University	Delaware
	Owens Technical College	Perrysburg
	Saint John College of Cleveland	Cleveland
	Sinclair Community College	Dayton
	Stark Technical College	Canton
	Tiffin University	Tiffin
	United Theological Seminary	Dayton
	University of Cincinnati	Cincinnati
	University of Dayton	Dayton
	University of Toledo	Toledo
	Urbana College	Urbana
	Washington Technical College	Marietta
	Wittenberg University	Springfield
	Wright State University	Dayton
	Xavier University	Cincinnati
	Youngstown State University	Youngstown
OK	Bacone College	Muskogee
	Bartlesville Weslyan College	Bartlesville
	Bethany Nazarene College	Bethany
	Cameron University	Lawton
	Carl Albert Junior College	Poteau
	Central State University	Edmond
	Claremore Junior College	Claremore
	Connors State College	Warner
	East Central Oklahoma State University	Ada
	Eastern Oklahoma State College	Wilburton
	El Reno Junior College	El Reno
	Hillsdale Free Will Baptist College	Moore
	Midwest Christian College	Oklahoma City
	Murray State College	Tishomingo
	Northeastern Oklahoma Agricultural and Mechanical College	Miami
	Northeastern Oklahoma State University	Tahlequah
	Northern Oklahoma College	Tonkawa
	Northwesterm Oklahoma State University	Alva
	Oklahoma Baptist University	Shawnee
	Oklahoma Christian College	Oklahoma City
	Oklahoma City University	Oklahoma City
	Oklahoma Panhandle State University	Goodwell
	Oklahoma School of Business, Accountancy, Law and Finance	Tulsa
	Oklahoma State University-Main Campus	Stillwater
	Oklahoma State University-Oklahoma City	Oklahoma City
	Oral Roberts University	Tulsa
	Oscar Rose Junior College	Midwest City
	Phillips University	Enid
	Saint Gregory's College	Shawnee
	Sayre Junior College	Sayre
	Seminole Junior College	Seminole
	Southeastern Oklahoma State University	Durant
	South Oklahoma City Junior College	Oklahoma City
	Southwestern College	Oklahoma City
	Tulsa Junior College	Tulsa
	University of Oklahoma-Central Office	Norman

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	University of Oklahoma-Health Science Center	Oklahoma City
	University of Science and Arts of Oklahoma	Chickasha
	University of Tulsa	Tulsa
	Western Oklahoma State College	Altus
OR	Blue Mountain Community College	Pendleton
	Chemeketa Community College	Salem
	Clackamas Community College	Oregon City
	Clatsop Community College	Astoria
	Columbia Christian College	Portland
	Concordia College	Portland
	George Fox College	Newberg
	Judson Baptist College	Portland
	Lane Community College	Eugene
	Lewis and Clark College	Portland
	Linfield College	McMinnville
	Linn-Benton Community College	Albany
	Marylhurst Education Center	Marylhurst
	Mount Hood Community College	Gresham
	Multnomah School of the Bible	Portland
	Museum Art School	Portland
	Oregon State Higher Education District	
	Eastern Oregon State College	La Grande
	Oregon College of Education	Monmouth
	Oregon Institute of Technology	Klamath Falls
	Oregon State University	Corvallis
	Portland State University	Portland
	Southern Oregon State College	Ashland
	University of Oregon-Health Sciences Center	Portland
	Pacific University	Forest Grove
	Reed College	Portland
	Southwestern Oregon Community College	Coos Bay
	Treasure Valley Community College	Ontario
	Umpqua Community College	Rosenburg
	University of Portland	Portland
	Warner Pacific College	Portland
	Western Baptist Bible College	Salem
	Western Conservative Baptist Seminary	Portland
	Western Evangelical Seminary	Portland
	Williamette University	Salem
PA	Allegheny College	Meadville
	Allentown College of St. Francis De Sales	Center Valley
	Alliance College	Cambridge Springs
	Beaver College	Glenside
	Bloomsburg State College	Bloomsburg
	Bucks County Community College	Newton
	Butler County Community College	Butler
	Cabrini College	Radnor
	California State College	California
	Carlow College	Pittsburgh
	Carnegie-Mellon University	Pittsburgh
	Cedar Crest College	Allentown
	Chestnut Hill College	Philadelphia
	Cheyney State College	Cheyney
	Clarion State College	Clarion
	Community College of Allegheny County	Pittsburgh
	Community College of Beaver County	Monaca
	Community College of Philadelphia	Philadelphia
	Delaware Valley College of Science and Agriculture	Doylestown

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Dickinson College	Carlisle
	Drexel University	Philadelphia
	The Dropsie University	Philadelphia
	Duquesne University	Pittsburgh
	Eastern College	Saint Davids
	East Stroudsburg State College	East Stroudsburg
	Edinboro State College	Edinboro
	Franklin-Marshall College	Lancaster
	Gannon College	Erie
	Geneva College	Beaver Falls
	Gettysburg College	Gettysburg
	Gwynedd-Mercy College	Gwynedd Valley
	Harcum Junior College	Bryn Mawr
	Haverford College	Haverford
	Indiana University of Pennsylvania	Indiana
	Juniata College	Huntingdon
	Keystone Junior College	La Plume
	King's College	Wilkes-Barre
	Lafayette College	Easton
	La Roche College	Allison Park
	La Salle College	Philadelphia
	Lehigh University	Bethlehem
	Lincoln University	Lincoln University
	Lock Haven State College	Lock Haven
	Lycoming College	Williamsport
	Mansfield State College	Mansfield
	Marywood College	Scranton
	Mercyhurst College	Erie
	Millersville State College	Millersville
	Montgomery County Community College	Blue Bell
	Northeastern Christian Junior College	Villanova
	Pennsylvania State University	University Park
	Philadelphia College of Pharmacy and Science	Philadelphia
	Point Park College	Pittsburgh
	Reading Area Community College	Reading
	Saint Fidelis College	Herman
	Saint Francis College	Loretto
	Saint Joseph's College	Philadelphia
	Saint Vincent College	Latrobe
	Seton Hill College	Greensburg
	Slippery Rock State College	Slippery Rock
	Spring Garden College	Chestnut Hill
	Susquehanna University	Selinsgrove
	Swarthmore College	Swarthmore
	Temple University	Philadelphia
	University of Pennsylvania	Philadelphia
	University of Pittsburg	Pittsburgh
	University of Scranton	Scranton
	Ursinus College	Collegeville
	Villa Maria College	Erie
	Villanova University	Villanova
	Waynesburg College	Waynesburg
	West Chester State College	West Chester
	Westminster College	New Wilmington
	Widener College	Chester
	Wilkes College	Wilkes-Barre
	Williamsport Area Community College	Williamsport
	Wilson College	Chambersburg
PR	Inter American University of Puerto Rico	San German
	The Catholic University of Puerto Rico	Ponce
	University of Puerto Rico	Mayaguez
	University of Puerto Rico	Rio Pedras

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
RI	Brown University	Providence
	Providence College	Providence
	Roger Williams College	Bristol
	University of Rhode Island	Kingston
SC	Aiken Technical Education Center	Aiken
	Baptist College	Charleston
	Bob Jones University	Greenville
	Central Wesleyan College	Central
	Citadel Military College of South Carolina	Charleston
	Claflin College	Orangeburg
	Clemson University	Clemson
	Coastal Carolina College	Conway
	Coker College	Hartsville
	College of Charleston	Charleston
	Columbia College	Columbia
	Columbia Bible College	Columbia
	Converse College	Spartanburg
	Erskine College	Due West
	Florence-Darlington Technical College	Florence
	Francis Marion College	Florence
	Furman University	Greenville
	Greenville Technical College	Greenville
	Lander College	Greenwood
	Limestone College	Gaffney
	Morris College	Sumter
	Newberry College	Newberry
	North Greenville College	Tigerville
	Orangeburg-Calhoun Technical College	Orangeburg
	Piedmont Technical College	Greenwood
	South Carolina State College	Orangeburg
	Sumter Area Technical College	Sumter
	Tri County Technical College	Pendleton
	Trident Technical College	North Charleston
	University of South Carolina	Columbia
	University of South Carolina at Aiken	Aiken
	University of South Carolina at Beaufort	Beaufort
	University of South Carolina at Spartanburg	Spartanburg
	University of South Carolina at Union	Union
	Voorhees College	Denmark
	Winthrop College	Rock Hill
	Wofford College	Spartanburg
SD	Augustana College	Sioux Falls
	Black Hills State College	Spearfish
	Dakota Wesleyan University	Mitchell
	Freeman Junior College	Freeman
	National College of Business	Rapid City
	Northern State College	Aberdeen
	Presentation College	Aberdeen
	Sioux Falls College	Sioux Falls
	South Dakota School of Mines and Technology	Rapid City
	South Dakota State University	Brookings
	University of South Dakota-Springfield	Springfield
TN	Aquinas Junior College	Nashville
	Austin Peay State University	Clarksville
	Belmont College	Nashville
	Carson-Newman College	Jefferson City
	Chattanooga State Technical Community College	Chattanooga

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Christian Brothers College	Memphis
	Cleveland State Community College	Cleveland
	Columbia State Community College	Columbia
	Covenant College	Lookout Mountain
	Cumberland College	Lebanon
	David Lipscomb College	Nashville
	Dyersburg State Community College	Dyersburg
	East Tennessee State University	Johnson City
	Fisk University	Nashville
	Freed-Hardeman College	Henderson
	Free Will Baptist Bible College	Nashville
	George Peabody College for Teachers	Nashville
	Hiwassee College	Madisonville
	Jackson State Community College	Jackson
	King College	Bristol
	Knoxville College	Knoxville
	Lambuth College	Jackson
	LeMoyne-Owen College	Memphis
	Martin College	Pulaski
	Memphis State University	Memphis
	Middle Tennessee State University	Murfreesboro
	Milligan College	Milligan College
	Nashville State Technical Institute	Nashville
	Roane State Community College	Harriman
	Shelby State Community College	Memphis
	State Technical Institute at Memphis	Memphis
	Steed College	Johnson City
	Tennessee Technological University	Cookeville
	Tennessee Wesleyan College	Athens
	University of the South	Sewanee
	University of Tennessee	Knoxville
	University of Tennessee Center for Health Sciences	Memphis
	University of Tennessee at Martin	Martin
	University of Tennessee at Nashville	Nashville
	Vanderbilt University	Nashville
	Volunteer State Community College	Gallatin
	Walters State Community College	Morristown
TX	Abilene Christian University	Abilene
	Alvin Community College	Alvin
	Amarillo College	Amarillo
	American Technological University	Killeen
	Angelina College	Lufkin
	Angelo State University	San Angelo
	Austin College	Sherman
	Austin Presbyterian Technological Seminary	Austin
	Baylor College of Dentistry	Dallas
	Baylor College of Medicine	Houston
	Baylor University	Waco
	Bee County College	Beeville
	Blinn College	Brenham
	Brazosport College	Lake Jackson
	Cisco Junior College	Cisco
	Clarendon College	Clarendon
	College of the Mainland	Texas City
	Concordia Lutheran College	Austin
	Cooke County College	Gainesville
	Dallas Bible College	Dallas
	Dallas Christian College	Dallas
	Dallas County Community College District	
	Eastfield College	Mesquite
	El Centro College	Dallas
	Mountain View College	Dallas
	Richland College	Dallas

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Dallas Theological Seminary	Dallas
	Del Mar College	Corpus Christi
	DeVry Institute of Technology	Dallas
	East Texas Baptist College	Marshall
	East Texas State University	Commerce
	El Paso Community College	El Paso
	Frank Phillips College	Borger
	Galveston College	Galveston
	Grayson College	Denison
	Gulf Coast Bible College	Houston
	Hardin-Simmons University	Abilene
	Henderson County Junior College	Athens
	Houston Baptist University	Houston
	Houston Community College	Houston
	Howard College at Big Spring	Big Spring
	Howard Payne University	Brownwood
	Huston-Tillotson College	Austin
	Incarnate Word College	San Antonio
	Jacksonville College	Jacksonville
	Jarvis Christian College	Hawkins
	Kilgore College	Kilgore
	Lamar University	Beaumont
	Laredo Junior College	Laredo
	Lee College	Baytown
	Le Tourneau College	Longview
	Lon Morris College	Jacksonville
	Lubbock Christian College	Lubbock
	McLennan Community College	Waco
	McMurry College	Abilene
	Midland College	Midland
	Midwestern State University	Wichita Falls
	Navarro College	Corsicana
	North Harris County College	Houston
	North Texas State University	Denton
	Odessa College	Odessa
	Our Lady of the Lake University of San Antonio	San Antonio
	Pan American University	Edinburg
	Panola Junior College	Carthage
	Ranger Junior College	Ranger
	Rice University	Houston
	Saint Edward's University	Austin
	Sam Houston State University	Huntsville
	San Antonio College	San Antonio
	San Jacinto College	Pasadena
	Schreiner College	Kerrville
	Southern Bible College	Houston
	Southern Methodist University	Dallas
	South Plains College	Lovelland
	South Texas College of Law	Houston
	Southwestern Assemblies of God College	Waxahachie
	Southwestern Baptist Theological Seminary	Fort Worth
	Southwestern Christian College	Terrell
	Southwestern Union College	Keene
	Southwestern University	Georgetown
	Southwest Texas State University	San Marcos
	Stephen F. Austin State University	Nacogdoches
	Tarleton State University	Stephenville
	Tarrant County Junior College-Northeast Campus	Hurst
	Tarrant County Junior College-Northwest Campus	Fort Worth
	Tarrant County Junior College-South Campus	Fort Worth
	Texarkana College	Texarkana
	Texas A & I University	Kingsville

APPENDIX V
CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Texas A & I University-Corpus Christi	Corpus Christi
	Texas A & I University-Laredo	Laredo
	Texas A & M University-Main Campus	College Station
	Texas A & M University Moody College of Marine Sciences and Maritime Resources	Galveston
	Texas Christian University	Fort Worth
	Texas College	Tyler
	Texas Lutheran College	Seguin
	Texas Southmost College	Brownsville
	Texas State Technical Institute-James Connally Campus	Waco
	Texas State Technical Institute-Mid-Continent Campus	Amarillo
	Texas State Technical Institute-Rio Grande Campus	Harlingen
	Texas Tech University	Lubbock
	Texas Wesleyan College	Fort Worth
	Texas Woman's University	Denton
	Trinity University	San Antonio
	Tyler Junior College	Tyler
	University of Dallas	Irving
	University of Houston-Main Campus	Houston
	University of Houston-Clear Lake City	Houston
	University of Houston-Victoria Campus	Victoria
	University of Texas-Arlington	Arlington
	University of Texas-Austin	Austin
	University of Texas at Dallas	Richardson
	University of Texas-El Paso	El Paso
	University of Texas Health Science Center at Dallas	Dallas
	University of Texas Health Science Center at Houston	Houston
	University of Texas Medical Branch at Galveston	Galveston
	University of Texas-San Antonio	San Antonio
	Vernon Regional Junior College	Vernon
	Victoria College	Victoria
	Weatherford College	Weatherford
	Western Texas College	Snyder
	West Texas State Universtiy	Canyon
	Wharton County Junior College	Wharton
	Wiley College	Marshall
UT	Brigham Young University	Provo
	Stevens Henager College	Ogden
	University of Utah	Salt Lake City
	Utah Higher Education System Office	
	University of Utah	Salt Lake City
	Utah State University	Logan
	Southern Utah State College	Cedar City
	Weber State College	Ogden
	College of Eastern Utah	Price
	Dixie College	Saint George
	Snow College	Ephraim
	Utah Technical College at Salt Lake City	Salt Lake City
	Westminster College	Salt Lake City

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
VT	Champlain College	Burlington
	Johnson State College	Johnson
	Lyndon State College	Lyndonville
	Marlboro College	Marlboro
	Middlebury College	Middlebury
	Norwich University	Northfield
	Saint Michael's College	Winooski
	School for International Training	Brattleboro
	Southern Vermont College	Bennington
	Trinity College	Burlington
	University of Vermont and State Agriculture College	Burlington
	Vermont Institute of Community Involvement	South Burlington
	Vermont Technical College	Randolph Center
	Windham College	Putney
VA	Averett College	Danville
	Bridgewater College	Bridgewater
	College of William and Mary	Williamsburg
	Eastern Mennonite College	Harrisonburg
	Eastern Virginia Medical School	Norfolk
	Emory and Henry College	Emory
	Ferrum College	Ferrum
	Hampton Institute	Hampton
	Institute of Textile Technology	Charlottesville
	J. Sargeant Reynolds Community College	Richmond
	Madison University	Harrisonburg
	Old Dominion University	Norfolk
	Radford College	Radford
	Randolph-Macon College	Ashland
	Randolph-Macon Woman's College	Lynchburg
	Saint Paul's College	Lawrenceville
	University of Virginia	Charlottesville
	Virginia Intermont College	Bristol
	Virginia Military Institute	Lexington
	Virginia Polytechnic Institute and State University	Blacksburg
	Virginia Wesleyan College	Norfolk
	Washington and Lee University	Lexington
	Wytheville Community College	Wytheville
WA	Bellevue Community College	Bellevue
	Big Bend Community College	Moses Lake
	Centralia College	Centralia
	Central Washington State College	Ellensburg
	Clark College	Vancouver
	Columbia Basin Community College	Pasco
	Cornish School of Allied Arts	Seattle
	Eastern Washington State College	Cheney
	Evergreen State College	Olympia
	Fort Steilacoom Community College	Tacoma
	Fort Wright College of the Holy Names	Spokane
	Gonzaga University	Spokane
	Grays Harbor College	Aberdeen
	Green River Community College	Auburn
	Highline Community College	Midway
	Lower Columbia College	Longview
	Lutheran Bible Institute of Seattle	Seattle
	Northwest College of the Assemblies of God	Kirkland
	Olympia Technical Community College	Olympia
	Olympic College	Bremerton
	Pacific Lutheran University	Tacoma
	Peninsula College	Port Angeles

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Seattle Community College District	
	North Seattle Community College	Seattle
	Seattle Community College-Central Campus	Seattle
	Seattle Community College-South Campus	Seattle
	Seattle University	Seattle
	Shoreline Community College	Seattle
	Skagit Valley College	Mount Vernon
	Tacoma Community College	Tacoma
	University of Puget Sound	Tacoma
	Walla Walla College	College Place
	Walla Walla Community College	Walla Walla
	Washington State Community College-District 5	
	Edmonds Community College	Lynnwood
	Everett Community College	Everett
	Washington State Community College-District 17	
	Spokane Falls Community College	Spokane
	Washington State University	Pullman
	Wenatchee Valley College	Wenatchee
	Western Washington State College	Bellingham
	Whatcom Community College	Bellingham
	Whitman College	Walla Walla
	Whitworth College	Spokane
	Yakima Valley College	Yakima
WV	Alderson Broaddus College	Phillippi
	Beckley College	Beckley
	Bethany College	Bethany
	Bluefield State College	Bluefield
	Concord College	Athens
	Davis and Elkins College	Elkins
	Glenville State College	Glenville
	Marshall University	Huntington
	Morris Harvey College	Charleston
	Parkersburg Community College	Parkersburg
	Potomac State College	Keyser
	Salem College	Salem
	West Liberty State College	West Liberty
	West Virginia Institute of Technology	Montgomery
	West Virginia University	Morgantown
	Wheeling College	Wheeling
WI	Alverno College	Milwaukee
	Beloit College	Beloit
	Blackhawk Technical Institute	Janesville
	Cardinal Stritch College	Milwaukee
	Carroll College	Waukesha
	Carthage College	Kenosha
	Concordia College	Milwaukee
	District One Technical Institute	Eau Claire
	Edgewood College	Madison
	Fox Valley Technical Institute	Appleton
	Gateway Technical Institute	Kenosha
	Holy Redeemer College	Waterford
	Institute of Paper Chemistry	Appleton
	Lakeshore Technical Institute	Cleveland
	Lawrence University	Appleton
	Madison Area Technical College	Madison
	Madison Business College	Madison
	Marian College of Fond Du Lac	Fond Du Lac
	Marquette University	Milwaukee
	Mid-State Technical Institute	Wisconsin Rapids
	Milton College	Milton

APPENDIX V

CATALOGS REVIEWED

STATE	INSTITUTION	LOCATION
	Milwaukee Area Technical College	Milwaukee
	Moraine Park Vocational, Technical and Adult Education Institute	Fond Du Lac
	Mount Mary College	Milwaukee
	Mount Senario College	Ladysmith
	Nicolet College and Technical Institute	Rhinelander
	North Central Technical Institute	Wausau
	Northeast Wisconsin Technical Institute	Green Bay
	Northland College	Ashland
	Ripon College	Ripon
	Saint Norbert College	De Pere
	Silver Lake College	Manitowoc
	Southwest Wisconsin Vocational-Technical Institute	Fennimore
	University of Wisconsin-Green Bay	Green Bay
	University of Wisconsin-Madison	Madison
	University of Wisconsin-Milwaukee	Milwaukee
	University of Wisconsin-System Office	Madison
	Viterbo College	La Crosse
	Waukesha County Technical Institute	Pewaukee
	Western Wisconsin Technical Institute	La Crosse
WY	Casper College	Casper
	Eastern Wyoming College	Torrington
	Laramie County Community College	Cheyenne
	Northwest Community College	Powell
	Sheridan College	Sheridan
	University of Wyoming	Laramie
	Western Wyoming Community College	Rock Springs